RAFA Solutions

DAnS

Data Analysis Software

Contents

"DAnS" Data Analysis Software is a graphical tool designed for viewing and analyzing logged data. Logged data is displayed in the form of waveforms on a graph. DanS works with most popular file formats such as Excel and TDMS. Software incorporates different types of analysis and measurements, as well as embedded calculator. Tool also allows to export logged or measured data to Excel or TDMS format files and create Report for the results in Excel, Word or PDF formats.

Getting Started

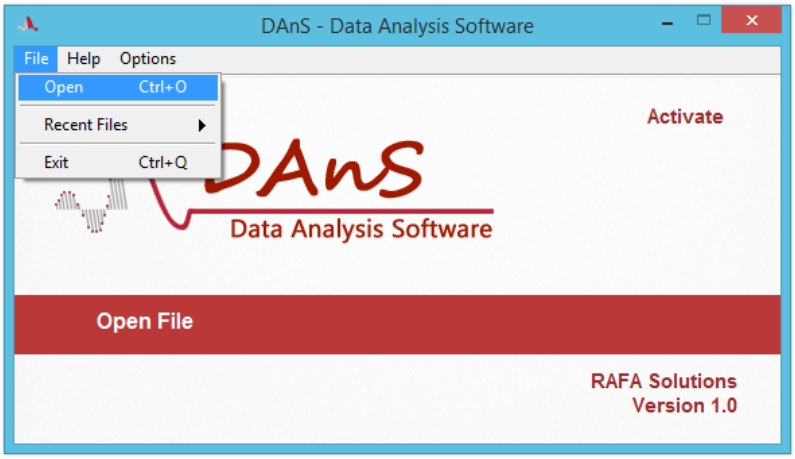
"DAnS" Software incorporates the following windows:

File Selection Window

File Selection Window is the first window which user sees after running the software.

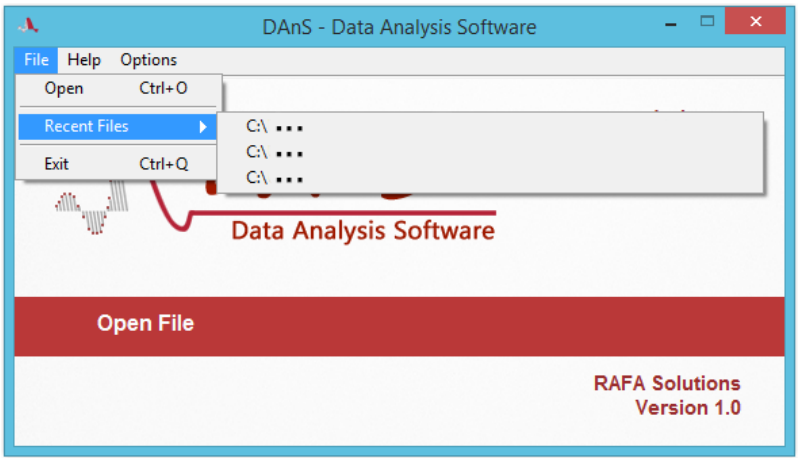
To open a file

- Press "OPEN FILE" button
  or
- Open a file from the menu bar: **File>Open**.

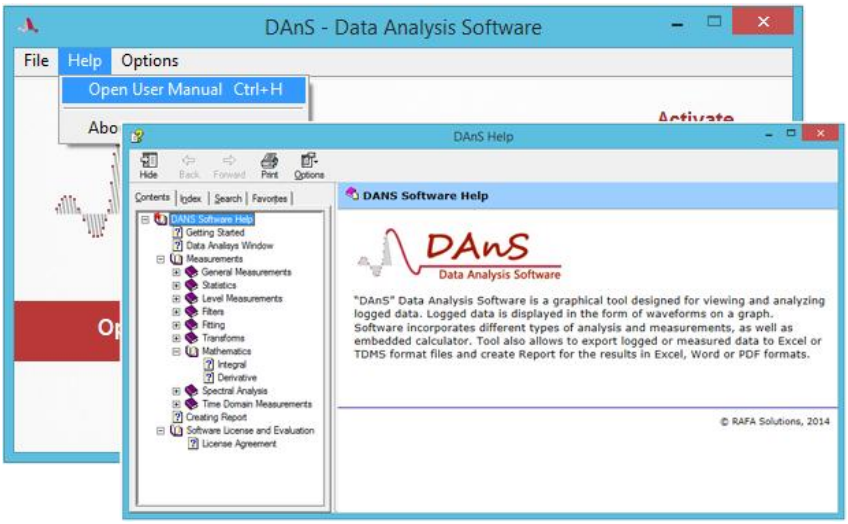


Window menu bar has three sections: File, Help and Options.

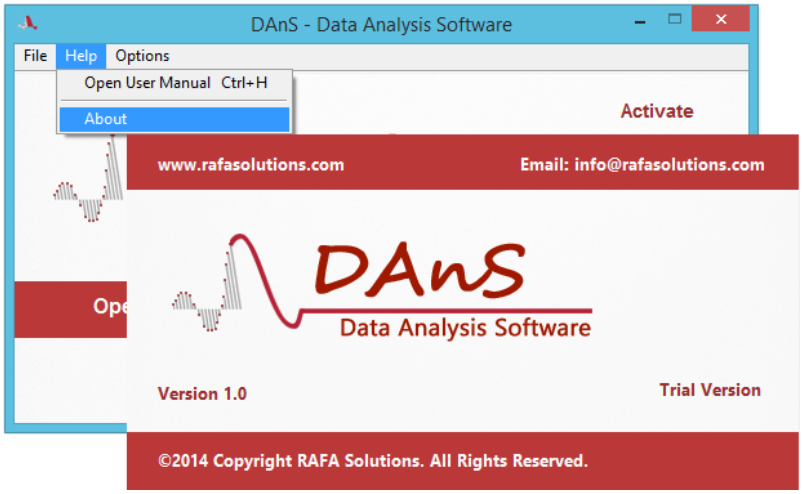
It is also possible to select one of the recently opened (up to 10) files from the menu bar: File>Recent Files.



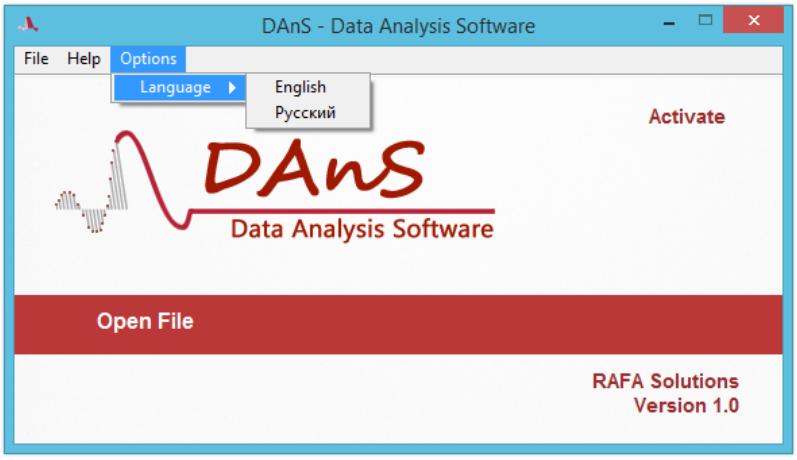
Help files can be opened from menu bar: Help>Open User Manual.



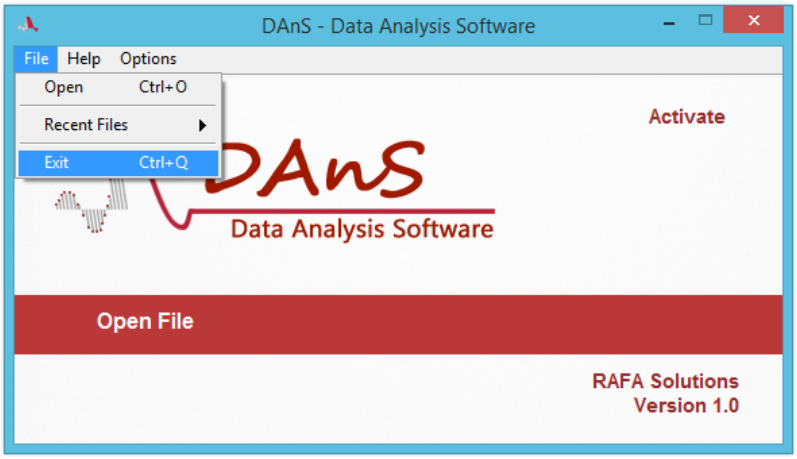
You can also read about the Software: Help>About.



Section "Options" contains menu of the software languages. It is possible to select either English or Russian language.

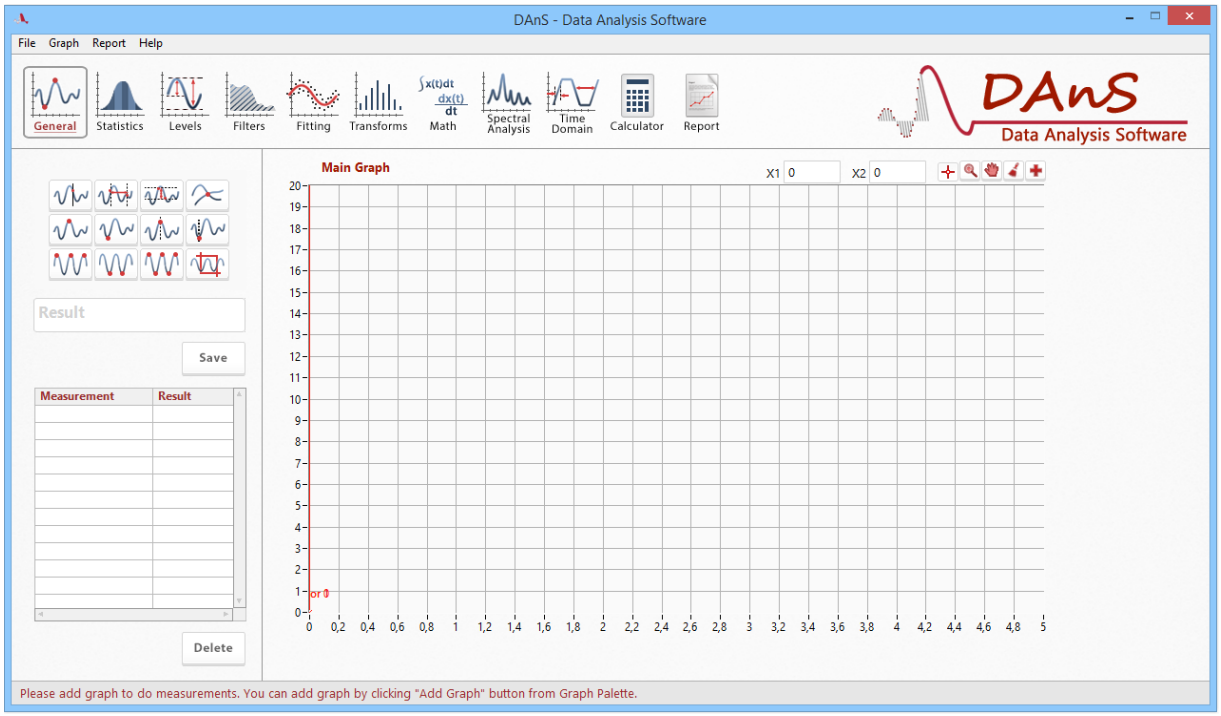


You can exit the Software by clicking “Close Window” button or from menu bar: File>Exit.



Data Analysis Window

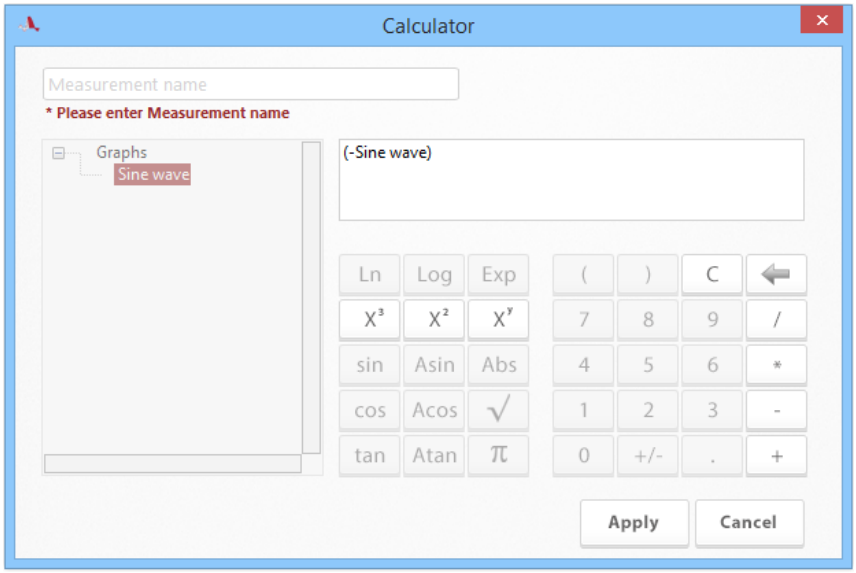
After selecting the file from File Selection Window, the window for data analysis will be opened.



You can do measurements and create reports from this interface. See detailed description of the window in the **"Data Analysis Window"** section of the Help.

Calculator Window

Embedded calculator can be opened by clicking "Calculator" button on the Data Analysis Window.

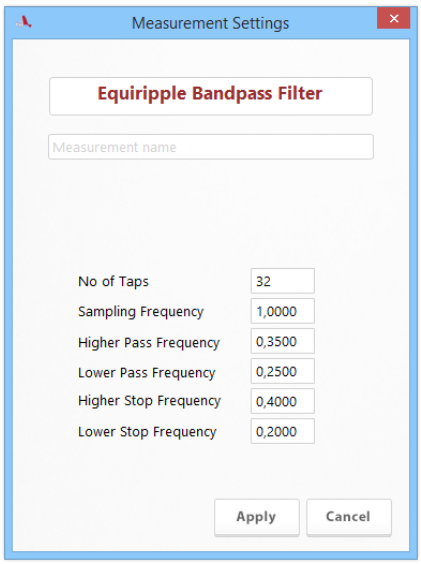


On the left part of the calculator window list with the plotted graphs from the file and saved measurements is presented. List includes multi- and single-point measurements. Double click the

item to add to the formula. You should add Measurement Name to the corresponding field if you want to save calculations done. Saved calculations will be added to the Measurement list as well.

Measurement Settings Window

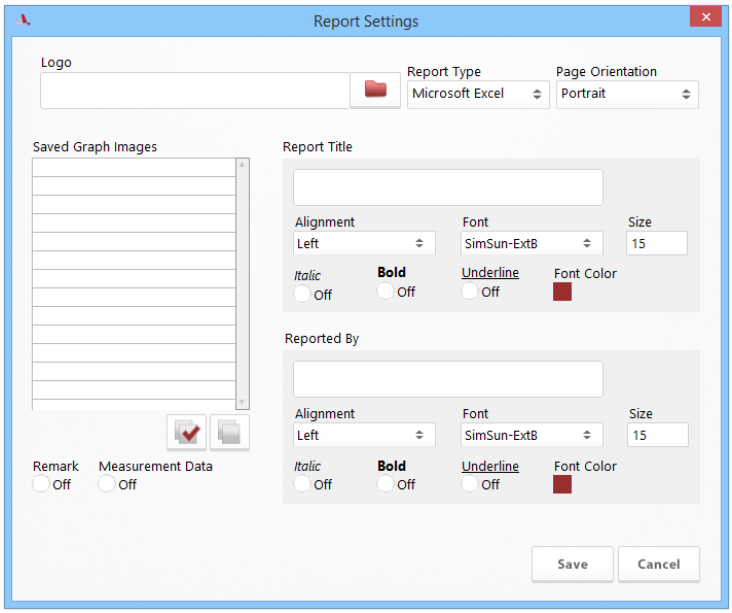
Measurement Settings window is opened each time one of the measurement buttons is clicked.



See detailed description of procedure for taking measurements in **"Measurements"** section of the Help. Settings and calculation methods for each measurement are described in appropriate sections of the Help.

Report Settings Window

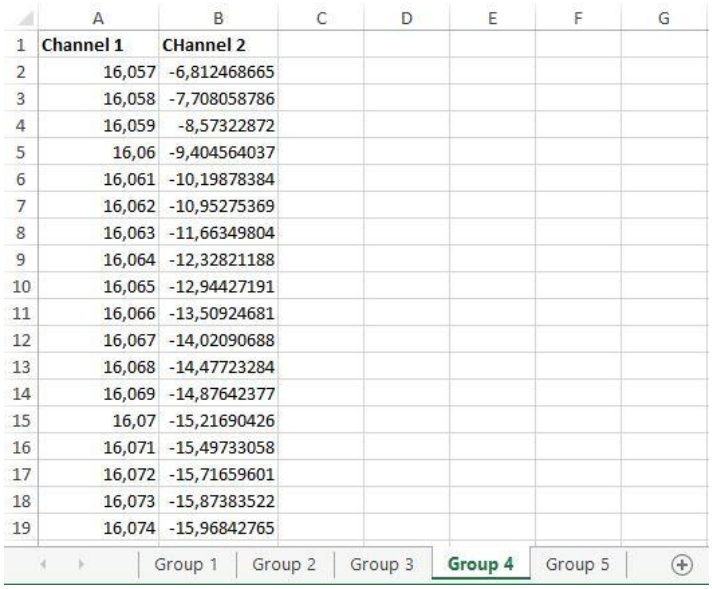
Report Settings Window is used to set options for the report.



See detailed description of procedure for creating report in **"Creating Report"** section of the Help.

Excel File Format

All Excel files should be in the following format:



	A	B	C	D	E	F	G
1	**Channel 1**	**CHannel 2**					
2	16,057	-6,812468665					
3	16,058	-7,708058786					
4	16,059	-8,57322872					
5	16,06	-9,404564037					
6	16,061	-10,19878384					
7	16,062	-10,95275369					
8	16,063	-11,66349804					
9	16,064	-12,32821188					
10	16,065	-12,94427191					
11	16,066	-13,50924681					
12	16,067	-14,02090688					
13	16,068	-14,47723284					
14	16,069	-14,87642377					
15	16,07	-15,21690426					
16	16,071	-15,49733058					
17	16,072	-15,71659601					
18	16,073	-15,87383522					
19	16,074	-15,96842765					

Group 1 | Group 2 | Group 3 | **Group 4** | Group 5

Each Excel sheet appears as a separate tree item in the Add Graph Window and can combine data from multiple channels. Data of each channel is written in the sheets in a separate column with the first line as a header and the rest is the data itself. In Add Graph Window these channels appear as sub-items of the particular Excel sheet.

Data Analysis Window

After selecting the file, the window for data analysis will be opened. You can do measurements and create reports for the data from this interface.

Menu Bar

On the top of the window menu bar is available. Menu bar has 5 main sections:

1. File

There are five main options available in this menu, which mostly refer to file operations.

a. Open file: Open a file from the menu bar: File>Open.

b. Recent files: There is a possibility to select one of the recently opened files from the menu bar: File>Recent Files.

c. Export Data: Exports plotted data to Excel or TDMS file. You should choose data from which graph you want to export - Main Graph or Measurements Graph.

d. Export Image: There is possibility to export Graph Images (Main Graph or Measurement Graph) in BMP, JPEG or PNG formats. If no format is chosen for the file, BMP format image will be saved. Choose directory where you want to export image from the browsing window and type file name.

e. Exit: Select this option if you want to close Data Analysis Window.

2. Graph

In this palette options for Measurement Graph are combined.

a. Show Measurement Graph: When Software is opened Measurement Graph is hidden. Select this option if you want to show it.

b. Hide Measurement Graph: Select this option if you want to hide Measurement Graph.

3. Report

In this menu options for Report are combined:

a. Save Image for Report: Select this option if you want to save Graph Image for later use in report. You can choose to save image of Main Graph as well as the Measurement Graph.

b. Report Settings: Select this option to apply settings for report. “Report Settings” window will be opened.

4. Help

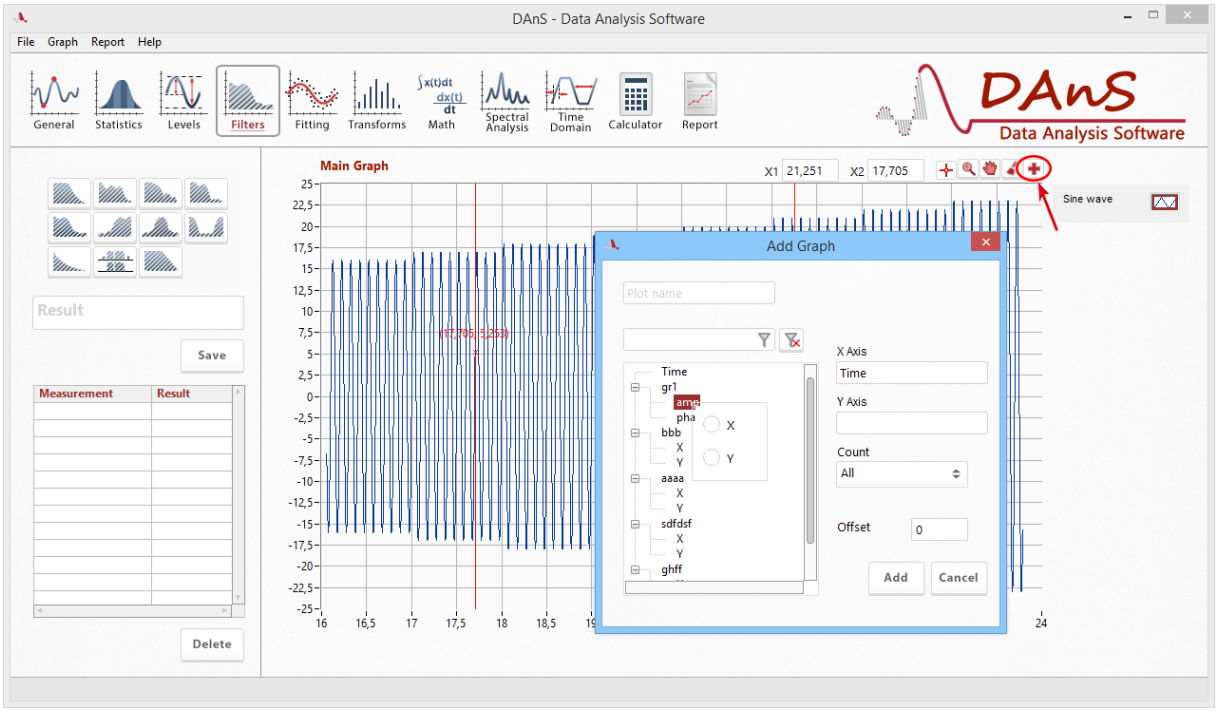
a. Open User Manual: This menu is for opening Help files for the Software.

b. Show Context Help Window: Displays short descriptions of functions.
Hovering on a particular object a small window with a short description of the object will appear. Clicking on More you can see a more detailed description of the object function.

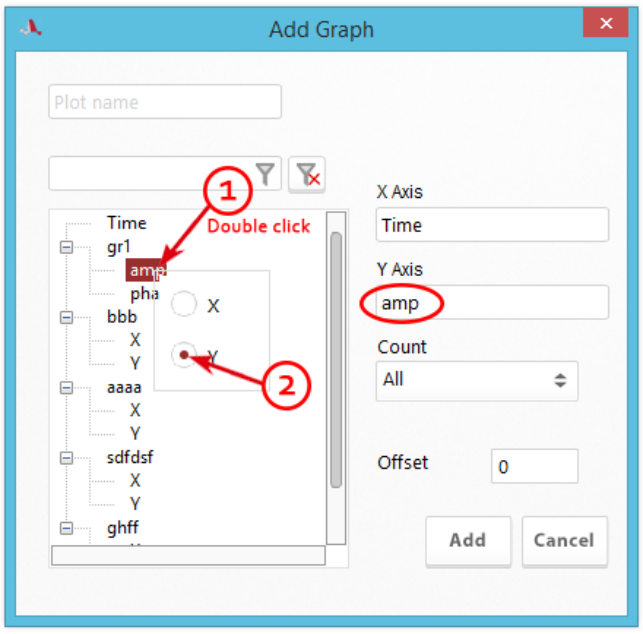
c. About: Reflect information about Software version, activation and the Company.

Plotting data

First of all, you should select data for applying measurements. This can be done by clicking add button from the graphs palette of the Main Graph (top right corner).



A separate interface will be opened for selecting channels from the file which you want to plot.



Channels appear in a tree, with their groups. A default channel for Time is added to the channels for the possibility to plot data versus Time. Double click the channel which you want to plot, a small window will be opened prompting to select an axis for the data. Applied X and Y axes' names will appear in the corresponding fields in the right part of the window. Field for X axis has "Time" value by default, which means data versus Time will be plotted if no other X axis is selected.

While working with big files, computer memory can get full, and it will not be possible to use the file. For big files channels should be read partially. It is possible to plot only selected number of points, with selected starting point (offset). If "All" option is selected for the "Count" parameter, whole channels selected for X and Y axes will be plotted. If you want to plot only part of the channels, mention number of points in the channels to plot selecting "other" option, and enter number of points. If for "Offset" parameter non-zero value is set, channels will be plotted starting from "Offset" numbered point.

Maximum permitted size for channel reading from a file is 1 mln elements. If channel length is more than 1 mln, only first 1 mln elements will be read.

Click "Add" button if you want to add selected plot to the graph, or "Cancel" to cancel the operation. The new Plot will be added to the graph with the name "Y vs X", where Y is the name of the channel selected as Y axis, and X for X axis. Number of plotted waveforms is not limited.

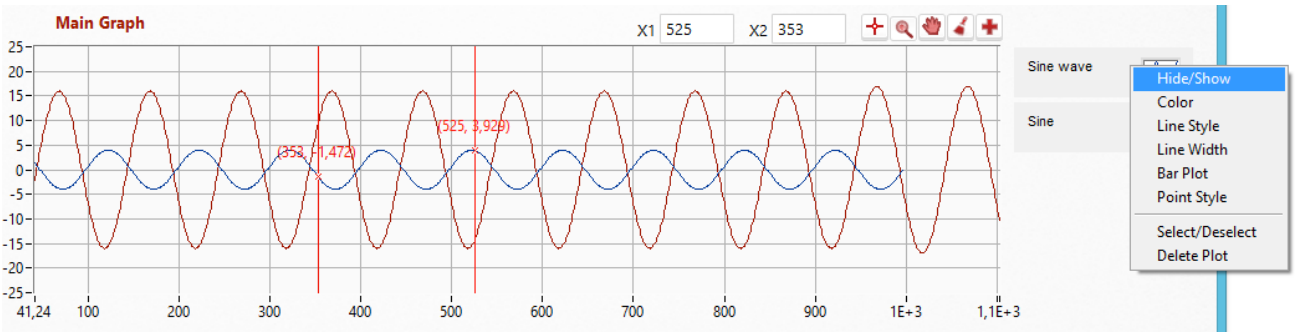
Plot Legends

Plot legends are located on the right side of each graph. You can change properties of the selected plot by right clicking its legend. To select or deselect plot click appropriate plot legend.

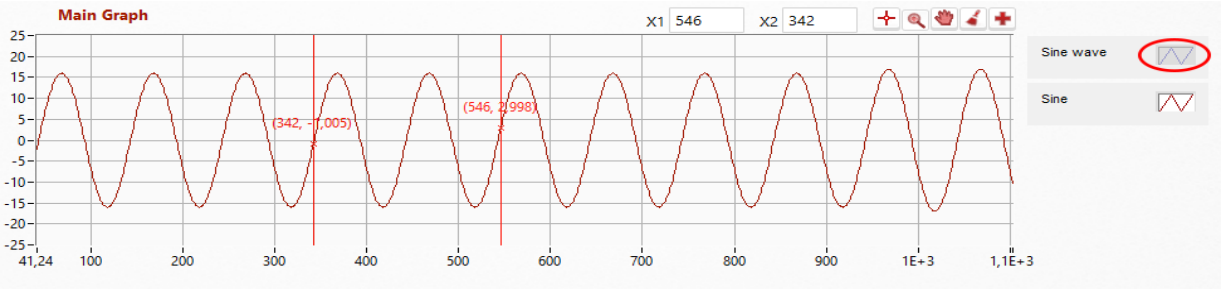
Shortcut menu for the legend includes the following items:

1. Hide/Show

Select this option if you want to hide visible waveform, or to show invisible one.



Plot legend for hidden waveform appears as grayed out.



2. Color

Select this option if you want to change the color of the selected waveform. Click the color box and select color from the color palette that appears.

3. Line Style

Select this option if you want to change the line style of the waveform. Select the style you want from the series of styles.

4. Line Width

Select this option to change the line width of the waveform.

5. Bar Plot

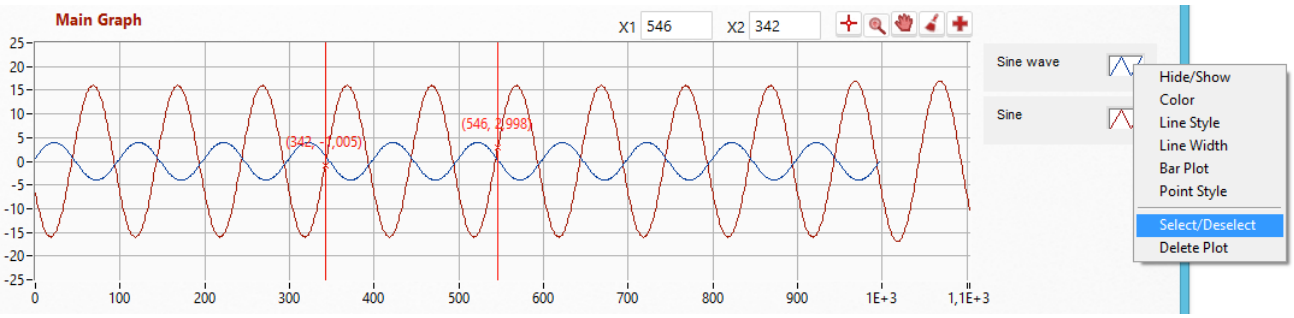
Select this option if you want to fill the bar for the selected waveform.

6. Point Style

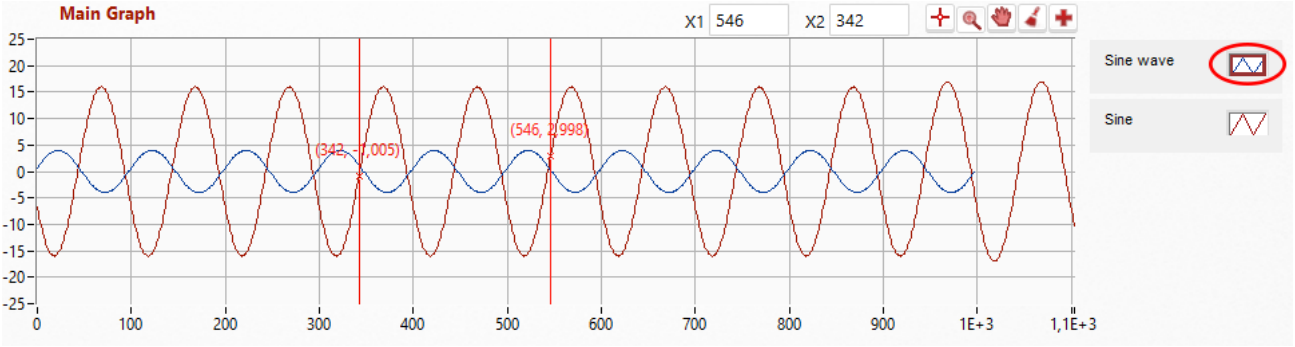
Select this option to change the point style of the waveform.

7. Select/Deselect

Select this option to make the waveform selected, or to deselect already selected waveform.



Plot legend for the selected plot appears with red borders.



8. Delete Plot

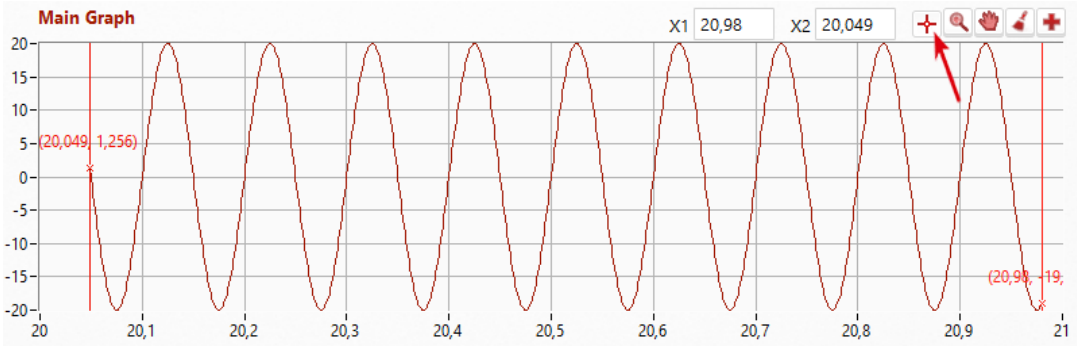
Select this option if you want to delete plotted waveform.

Graph Palette (Main Graph)

You can apply general changes to the graph from the Graph Palette. There are five options available from this palette:

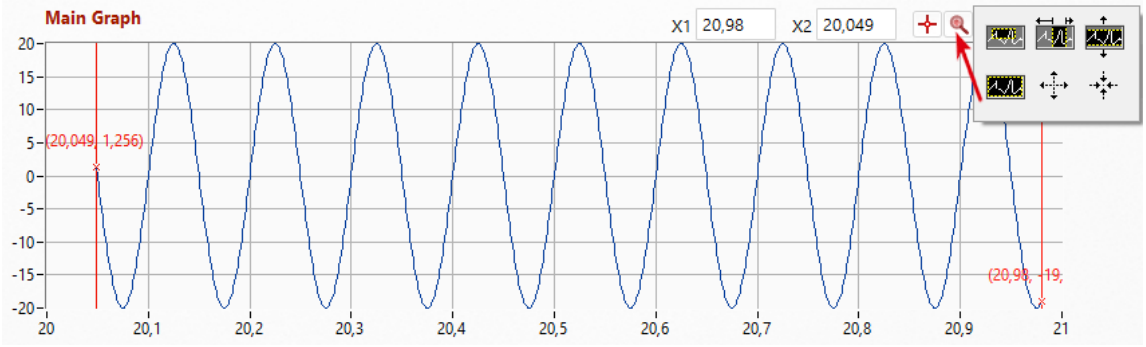
1. Cursor

Select this option if you want to move cursors of the graph.



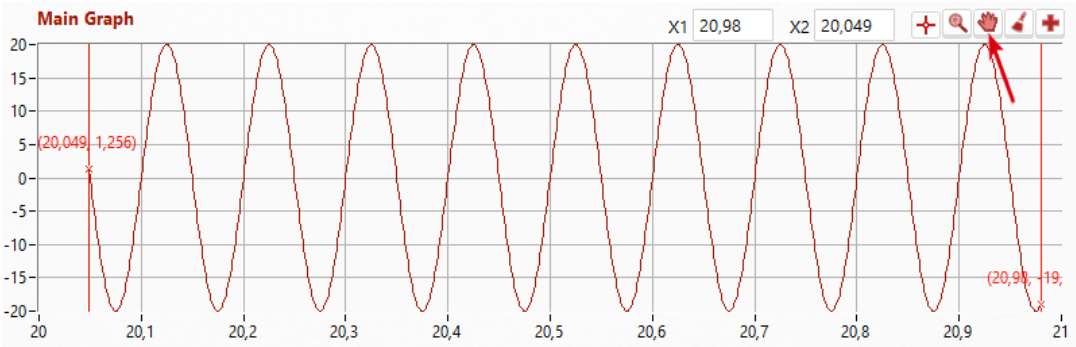
2. Zoom

Select one of zoom options to apply to graph.



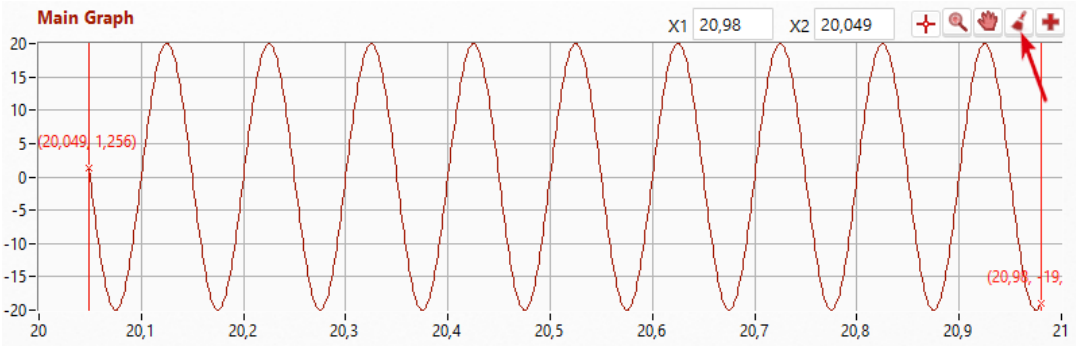
3. Hand Tool

Select this option to move the graph.



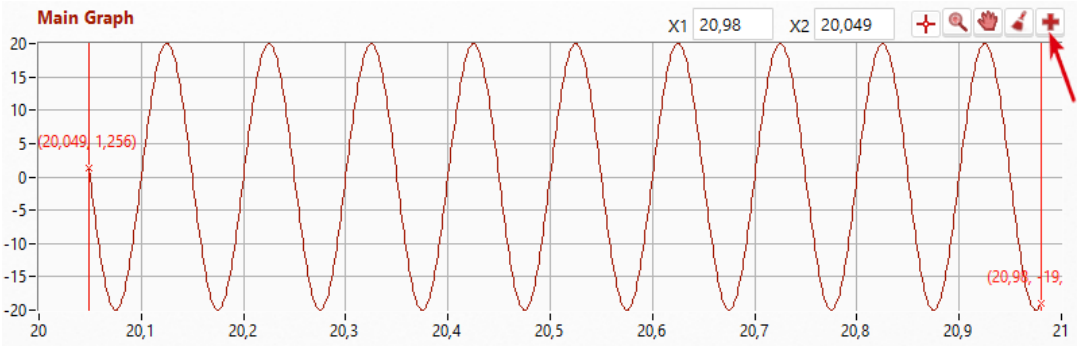
4. Clear Graph

Select this option to clear all plotted data.

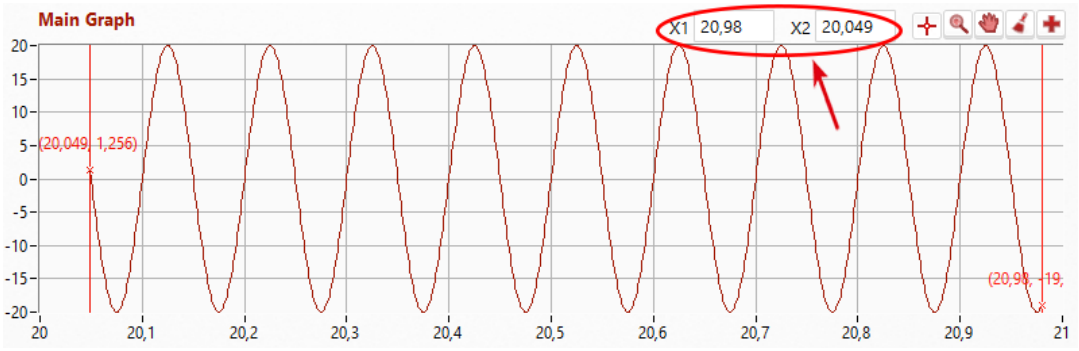


5. Add Graph

Select this option to add new waveform to already plotted waveforms. Detailed operation of this option is described in “Plotting data” section of the current Help file.



Main Graph has also an option to move cursors by giving X coordinates of the cursors. Enter first and second cursors' X coordinates in the X1 and X2 fields appropriately, above the Main Graph.

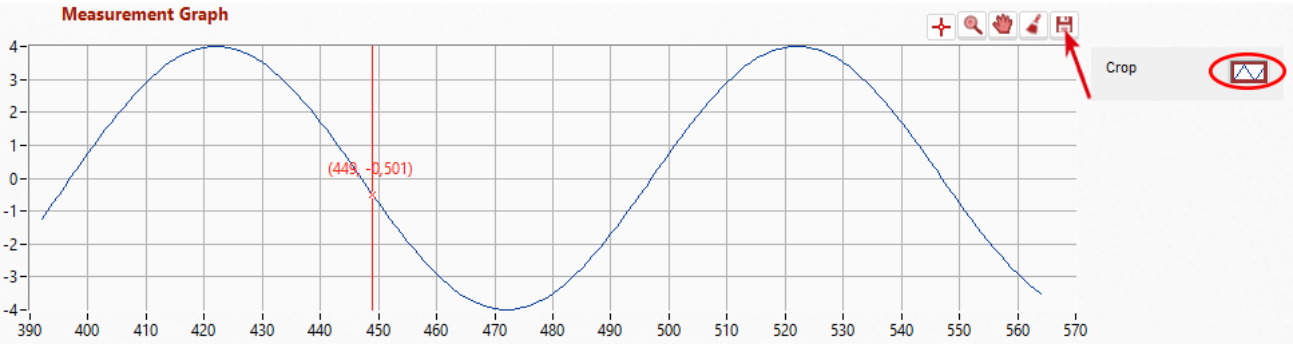


Graph Palette (Measurement Graph)

Graph palette of Measurement Graph has five options.

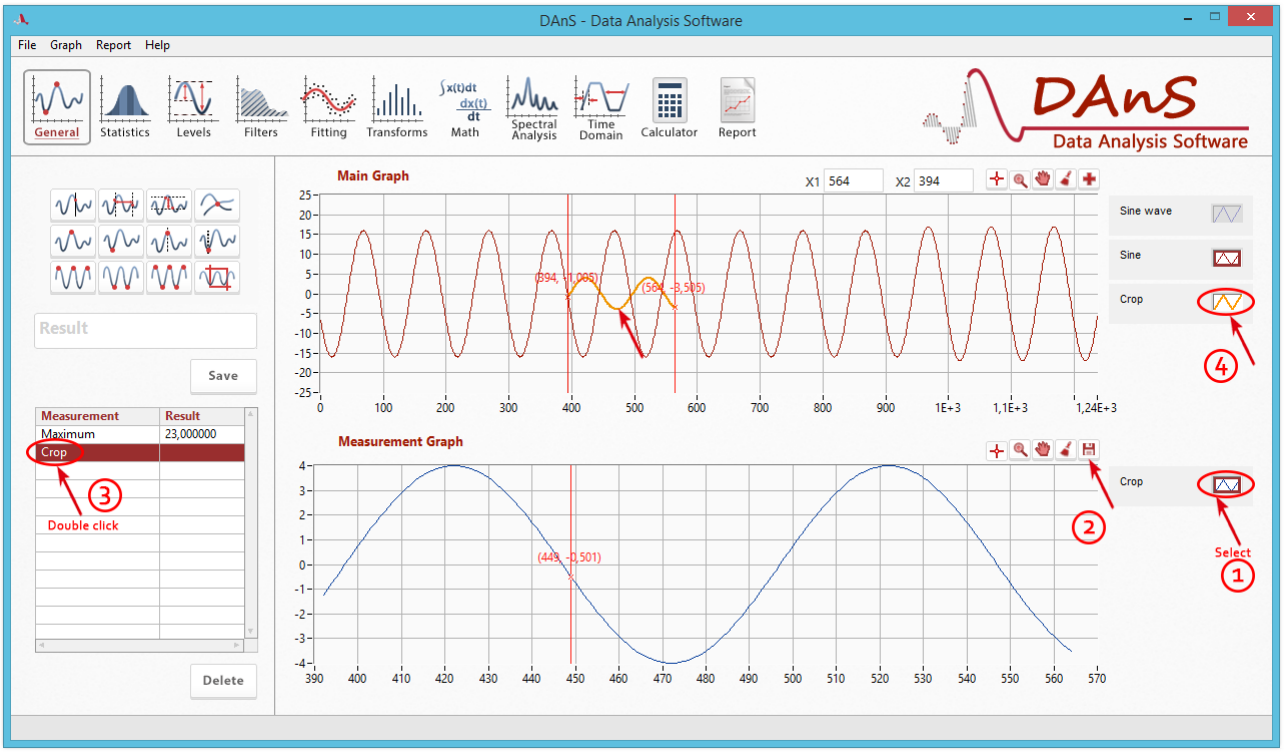
First four options - Cursor, Zoom, Hand Tool and Clear Graph are the same, as for the Main Graph. See detailed descriptions for these options in “Graph Palette (Main Graph)” section above.

The fifth option in Graphs Palette is “Save Graph”. This option saves data of the selected plots.



Names of the saved data appear in the Measurement list in the left part of the window.

You can add them to Main Graph by double clicking.



Groups of Measurements

On the top part of the window there is the list of Measurement Groups. Click one of the measurements to see its menu on the top left part of the window. By default “General Measurements” menu is opened. After The Menu of the selected type of measurements is opened the measurements can be done for the selected data.

Measurement list

All saved measurements appear in the Measurement list on the left bottom part of the window. You can select measurements from this list by clicking on the appropriate row of the list. Selected measurements can be deleted by clicking “Delete” button under the table.

Closing Data Analysis Window

Data Analysis Window can be closed by clicking “Close” button or from Menu Bar: File>Exit. After this action Main Window will be reopened, you can choose another TDMS file to work with, or close the Software.

Creating Report

"DAnS" software allows creating Reports in Excel, Word or PDF formats. Report can be created by clicking "Report" button on the "Data Analysis Window". Before creating the report appropriate settings should be set from the "Report Settings" window. The "Report Settings" window can be opened from the Report>Report Settings option in Menu bar. This window is also opened each time "Report" button is clicked on the "Data Analysis Window".

The following settings should be selected for the report:

1. Logo

Logo appears on the top left corner of the Report. If no logo is chosen, it will not appear in the report. Note, only JPEG or PNG formatted images can be selected for the logo.

2. Report type

This option defines file type for the Report. It is possible to choose Microsoft Excel, Microsoft Word and PDF formats. Note, in the computer you are using the following software should exist in order to generate report:

- Microsoft Excel

- Microsoft Word

- Any PDF reader and PDF printer/converter. You can download free pdf converter from http://www.foxitsoftware.com/.

3. Page Orientation

Defines orientation of the report page (Portrait or Landscape). Portrait page orientation is selected by default.

4. Saved Graph Images

This table shows images of graphs which were saved previously from the "Data Analysis Window". You can select graphs by double clicking on the graph name. Selected graphs will appear in the report file. All graphs are deselected by default.

You can select/deselect all Graph Images by click appropriate button located under the Image table.

5. Remark

If Remark is "On" Graph Image remarks will be included in the Report.

6. Measurement Data

If Measurement Data is "On" all single-point measurements will be included in the Report.

7. Report Title

Report Title appears on the top of the Report page. The following settings can be chosen for the Report Title: Alignment, Font, Size, Style (Italic, Bold, Underline), Color.

8. Reported By

Text inserted in the “Reported By” field appears on the bottom of the Report page. The following settings can be chosen for the text: Alignment, Font, Size, Style (Italic, Bold, Underline), Color.

Measurements

Measurement types

For easier use measurements are divided into groups, according to their types. There are nine groups of measurements:

1. General Measurements

This group includes general measurements which can be done on any type of waveforms. Group includes measurements, such as Maximum of the waveform, Peaks of the waveform and so on.

2. Statistical Measurements

Measurements in this group are for statistical analysis of the waveform. Examples for statistical measurements are calculation of root mean square, mean, variance, etc.

3. Level Measurements

This group combines measurements which concern signal level calculations, such as amplitude calculation, high/low state level calculation, etc.

4. Time Domain Measurements

Measurements in this group are for calculations which refer to time domain. Time domain measurements include transition, period, frequency calculation, etc.

5. Spectral Analysis

Measurements in this group perform different spectral analysis. These measurements should be applied to the waveform in time domain.

6. Filters

This group includes different types of filters. Filters can be applied to any type of signals in time domain. For correct results the selected waveform should be plotted vs Time.

7. Fitting

This group combines different methods for fitting data to known curves.

8. Mathematics

This group combines mathematical calculations, such as integral and derivative.

9. Transforms

This group includes different transforms for the waveforms, such as Fast Fourier transform, Walsh-Hadamard transform, Fast Hilbert transform, etc.

All measurements in these groups are described in details in corresponding chapters of this document.

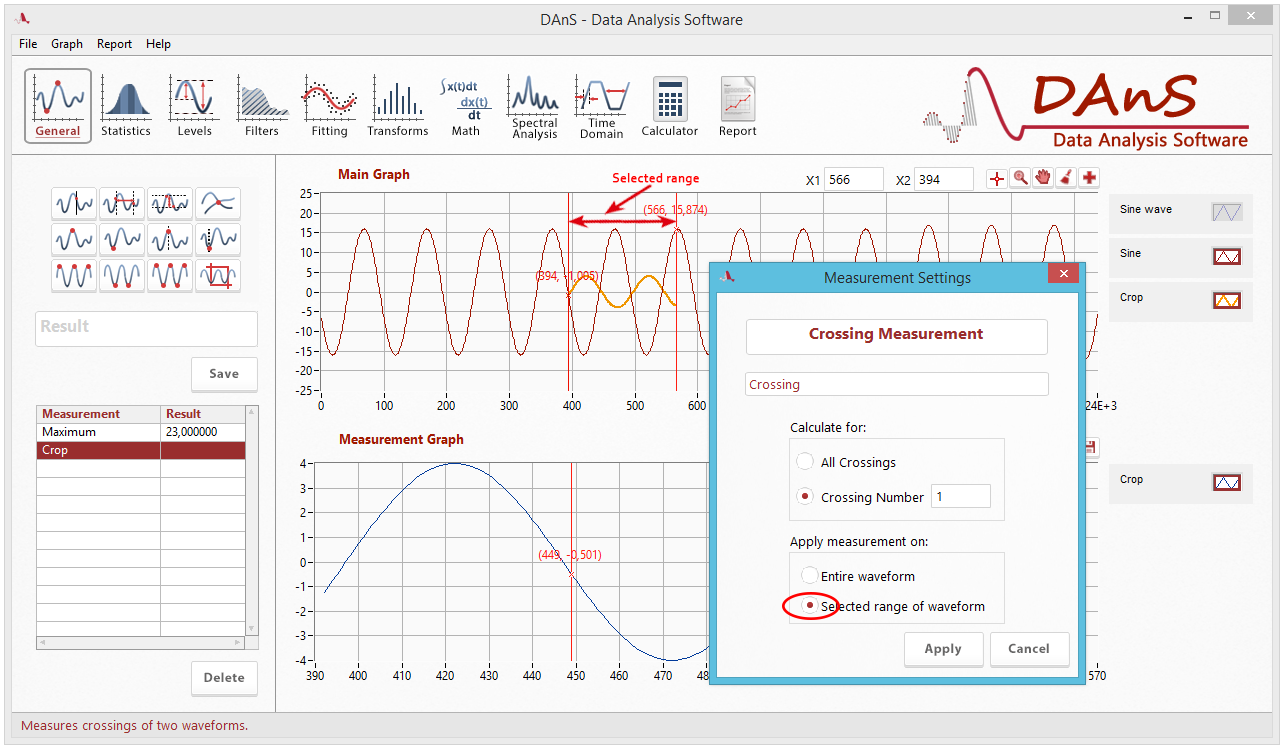
Select data for measurements

Measurements can be applied only on the waveforms which are plotted on the Main Graph. You should select the waveform you want to do measurements on from the list of waveforms plotted on the Main Graph by clicking on the plot legend or from Shortcut Menu by right clicking the plot legend and selecting “Select/Deselect” option. The selected plot legend is shown with red borders. By choosing “Select/Deselect” option second time or clicking on the selected plot it is possible to deselect it.

There are measurements which should be done on a single waveform, such as “Peaks”, “Valleys” and so on (in this case single plot should be selected), and there are those, for which two waveforms should be selected, for example “Crossing”. If you choose incorrect number of plots, a message will appear in the Status bar with appropriate warning. No measurement will be done in this case.

Selecting range for measurements

Before doing any measurement, Measurement Settings window for the selected measurement is being opened. You can do the measurement on the Entire Waveform or on the Selected range. In the case of selected range, measurement is being done on the part of the waveform within two cursors on the Main Graph.



Single-point and multipoint measurements

Single-point measurement result is a single value number. Examples for this kind of measurements are: Maximum, Delta X, Amplitude, Time Domain Measurement done for single pulse, etc.

Results for single-point measurements are shown on the left side of the software window. Measurement result is shown in “Result” window. To save measurement result you should click the “Save” button under “Result” window. Saved results are appearing in the “Measurements List” on the left side of the software window. It is also possible to use saved results in the calculator.

Multipoint measurement result is a waveform. Examples for multipoint measurements are: Peaks (if the selected waveform has multiple peaks), Peaks and Valleys, all fittings, all transforms and so on.

Multipoint measurements are being plotted on the Measurement Graph. You can show or hide this graph from Menu Bar. If you have done multipoint measurement and have not enabled Measurement Graph, a warning will come. From Measurement graph you can save selected Measurements for later use. Saved Multipoint measurement will appear in the measurements list. You can plot saved measurement on the Main Graph by double clicking it from the measurements list for later operations. You will also be able to use saved multipoint measurements in calculator.

General Measurements

This group includes general measurements which can be done on any type of waveforms. Group includes measurements, such as Maximum of the waveform, Peaks of the waveform and so on.

At X

Description

Returns the Y-axis value at a particular X-axis point of the waveform for the entire or selected range.

Measurement Category

General

Measurement Settings

X Value: Specifies the X value which corresponding Y value should be found.

Apply measurement on: Specifies the range for the measurement.

Two options exist for the measurement:

- Entire waveform
- Selected range of waveform

If the first option is selected, measurement is applied to the entire waveform, regardless of what is viewed, or selected with graph cursors.
If the second option is selected, measurement is applied only to the X range selected with the graph cursors.

Calculation

For provided X value returns the corresponding Y value.

Crossing

Description

Measures crossings of two waveforms for the entire or selected range. It is possible to find all or selected crossings.

Measurement Category

General

Measurement Settings

Method: Defines the method curves will be interpolated by.

- Nearest
- Linear
- Spline
- Cubic Hermite
- Lagrange

Accuracy: Defines the accuracy of the measurement. The smaller this parameter the bigger accuracy of the measurement is. Accuracy is a positive parameter, it cannot equal to 0 as well.

Calculate for: Specifies the crossings for which measurement should be done.

Two options exist for the measurement:

- All Crossings
- Crossing Number

If the first option is selected, all crossings of the waveforms are returned. If the second option is selected, selected crossing is returned.

Apply measurement on: Specifies the range for the measurement.

Two options exist for the measurement:

- Entire waveform
- Selected range of waveform

If the first option is selected, measurement is applied to the entire waveform, regardless of what is viewed, or selected with graph cursors.
If the second option is selected, measurement is applied only to the X range selected with the graph cursors.

Calculation

Crossing is calculated by finding points with the save values for two waveforms. After crossing of two waveforms is found, corresponding Y axis value is returned. If selected two waveforms don't have any crossings, "NaN" value is returned.

Delta X

Description Returns the delta X value of the waveform for the selected range.

Measurement Category

General

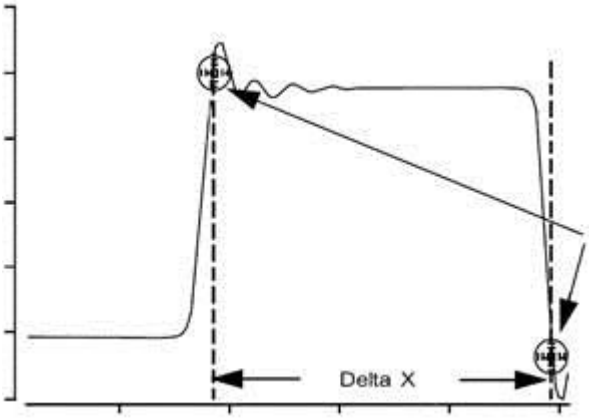
Measurement Settings

None

Calculation

Delta X is a difference between two X-axis points for the range of waveform selected with graph cursors.

Example of delta X calculation is shown below.



Delta Y

Description

Returns the delta Y value of the waveform for the selected range.

Measurement Category

General

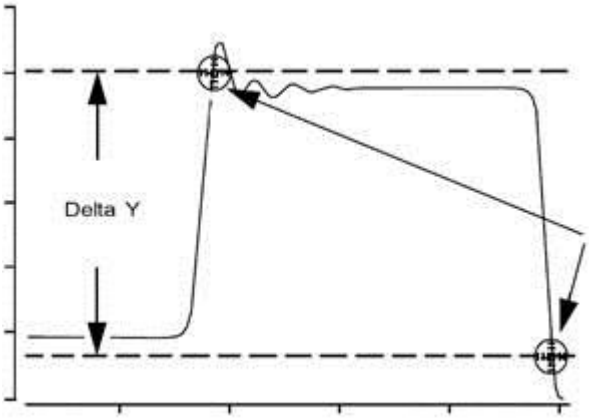
Measurement Settings

None

Calculation

Delta Y is a difference between two Y-axis points for the range of waveform selected with graph cursors.

Example of delta Y calculation is shown below.



Maximum

Description

Measures Maximum Value of the waveform for the entire or selected range.

Measurement Category

General

Measurement Settings

Apply measurement on: Specifies the range for the measurement.

Two options exist for the measurement:

- Entire waveform
- Selected range of waveform

If the first option is selected, measurement is applied to the entire waveform, regardless of what is viewed, or selected with graph cursors.

If the second option is selected, measurement is applied only to the X range selected with the graph cursors.

Calculation

Maximum value of the input sequence is returned.

Minimum

Description

Measures Minimum Value of the waveform for the entire or selected range.

Measurement Category

General

Measurement Settings

Apply measurement on: Specifies the range for the measurement.

Two options exist for the measurement:

- Entire waveform
- Selected range of waveform

If the first option is selected, measurement is applied to the entire waveform, regardless of what is viewed, or selected with graph cursors.

If the second option is selected, measurement is applied only to the X range selected with the graph cursors.

Calculation

Minimum value of the input sequence is returned.

X at Maximum

Description

Returns the X coordinate of the Maximum value of the waveform for the entire or selected range.

Measurement Category

General

Measurement Settings

Apply measurement on: Specifies the range for the measurement.

Two options exist for the measurement:

- Entire waveform
- Selected range of waveform

If the first option is selected, measurement is applied to the entire waveform, regardless of what is viewed, or selected with graph cursors.

If the second option is selected, measurement is applied only to the X range selected with the graph cursors.

Calculation

Finds the maximum value and returns corresponding X coordinate.

X at Minimum

Description

Returns the X coordinate of the Minimum value of the waveform for the entire or selected range.

Measurement Category

General

Measurement Settings

Apply measurement on: Specifies the range for the measurement.

Two options exist for the measurement:

- Entire waveform
- Selected range of waveform

If the first option is selected, measurement is applied to the entire waveform, regardless of what is viewed, or selected with graph cursors.

If the second option is selected, measurement is applied only to the X range selected with the graph cursors.

Calculation

Finds the minimum value and returns corresponding X coordinate.

Peaks

Description

Returns Peaks of the waveform for the entire or selected range.

Measurement Category

General

Measurement Settings

Threshold: Ignores peaks which amplitudes are less than threshold.

Width: Specifies the number of consecutive data points to use in the quadratic least squares fit. Width is coerced to a value greater than or equal to 3. The value should be no more than about 1/2 of the half-width of the peaks and can be much smaller (but > 2) for noise-free data. Width should be as small as possible but should be balanced against the possibility of false peak detection due to noise.

Apply measurement on: Specifies the range for the measurement.

Two options exist for the measurement:

- Entire waveform
- Selected range of waveform

If the first option is selected, measurement is applied to the entire waveform, regardless of what is viewed, or selected with graph cursors.

If the second option is selected, measurement is applied only to the X range selected with the graph cursors.

Calculation

Peaks are measured based on an algorithm that fits a quadratic polynomial to sequential groups of data points. The number of data points used in the fit is specified by width.

For each peak, the quadratic fit is tested against the threshold. Peaks with heights lower than threshold are ignored.

Valleys

Description

Returns Valleys of the waveform for the entire or selected range.

Measurement Category

General

Measurement Settings

Threshold: Ignores valleys which amplitudes are greater than threshold.

Width: Specifies the number of consecutive data points to use in the quadratic least squares fit. Width is coerced to a value greater than or equal to 3. The value should be no more than about 1/2 of the half-width of the valleys and can be much smaller (but > 2) for noise-free data. Width should be as small as possible but must be balanced against the possibility of false peak detection due to noise.

Apply measurement on: Specifies the range for the measurement.

Two options exist for the measurement:

- Entire waveform
- Selected range of waveform

If the first option is selected, measurement is applied to the entire waveform, regardless of what is viewed, or selected with graph cursors.

If the second option is selected, measurement is applied only to the X range selected with the graph cursors.

Calculation

Valleys are measured based on an algorithm that fits a quadratic polynomial to sequential groups of data points. The number of data points used in the fit is specified by width.

For each valley, the quadratic fit is tested against the threshold. Valleys with troughs higher than threshold are ignored.

Peaks and Valleys

Description

Returns Peaks and Valleys of the waveform for the entire or selected range.

Measurement Category

General

Measurement Settings

High Threshold: Ignores peaks which amplitudes are less than high threshold.

Low Threshold: Ignores valleys which amplitudes are greater than low threshold.

Width: Specifies the number of consecutive data points to use in the quadratic least squares fit. Width is coerced to a value greater than or equal to 3. The value should be no more than about 1/2

of the half-width of the peaks/valleys and can be much smaller (but > 2) for noise-free data. Width should be as small as possible but must be balanced against the possibility of false peak detection due to noise.

Apply measurement on: Specifies the range for the measurement.

Two options exist for the measurement:

- Entire waveform
- Selected range of waveform

If the first option is selected, measurement is applied to the entire waveform, regardless of what is viewed, or selected with graph cursors.

If the second option is selected, measurement is applied only to the X range selected with the graph cursors.

Calculation

Peaks and Valleys are measured based on an algorithm that fits a quadratic polynomial to sequential groups of data points. The number of data points used in the fit is specified by width.

For each peak and valley, the quadratic fit is tested against the high and low thresholds. Peaks with heights lower than high threshold and valleys with troughs higher than low threshold are ignored.

Crop

Description

Returns cropped part of the selected waveform.

Measurement Category

General

Measurement Settings

None

Calculation

Part of the selected waveform containing between two cursors is returned.

Statistics

Measurements in this group are for statistical analysis of the waveform. Examples for statistical measurements are calculation of root mean square, mean, variance, etc.

Mean

Description

Returns the mean of the waveform for the entire or selected range.

Measurement Category

Statistics

Measurement Settings

Apply measurement on: Specifies the range for the measurement.

Two options exist for the measurement:

- Entire waveform
- Selected range of waveform

If the first option is selected, measurement is applied to the entire waveform, regardless of what is viewed, or selected with graph cursors.

If the second option is selected, measurement is applied only to the X range selected with the graph cursors.

Calculation

Mean is calculated by the following equation:

$$\mu = \frac{1}{n}\sum_{i=0}^{n-1} x_i$$

Root Mean Square

Description

Returns the root mean square of the waveform for the entire or selected range.

Measurement Category

Statistics

Measurement Settings

Apply measurement on: Specifies the range for the measurement.

Two options exist for the measurement:

- Entire waveform
- Selected range of waveform

If the first option is selected, measurement is applied to the entire waveform, regardless of what is viewed, or selected with graph cursors.

If the second option is selected, measurement is applied only to the X range selected with the graph cursors.

Calculation

Root mean square is calculated by the following equation:

$$\psi = \sqrt{\frac{1}{n}\sum_{i=0}^{n-1}|x_i|^2}$$

Standard Deviation

Description

Returns the standard deviation of the waveform for the entire or selected range.

Measurement Category

Statistics

Measurement Settings

Weighting: Specifies whether to calculate population or sample standard deviation:

- Sample – 0(default)
- Population - 1

Apply measurement on: Specifies the range for the measurement.

Two options exist for the measurement:

- Entire waveform
- Selected range of waveform

If the first option is selected, measurement is applied to the entire waveform, regardless of what is viewed, or selected with graph cursors.

If the second option is selected, measurement is applied only to the X range selected with the graph cursors.

Calculation

Standard deviation is calculated by the following equation:

$$\sigma = \sqrt{\sum_{i=0}^{n-1} \frac{(x_i - \mu)^2}{w}},$$

where w is weighting and is «n-1» when weighting is set to sample and «n» when it is population.

Variance

Description

Returns the variance of the waveform for the entire or selected range.

Measurement Category

Statistics

Measurement Settings

Weighting: Specifies whether to calculate population or sample standard deviation:

- Sample – 0(default)
- Population - 1

Apply measurement on: Specifies the range for the measurement.

Two options exist for the measurement:

- Entire waveform
- Selected range of waveform

If the first option is selected, measurement is applied to the entire waveform, regardless of what is viewed, or selected with graph cursors.

If the second option is selected, measurement is applied only to the X range selected with the graph cursors.

Calculation

Variance is calculated by the following equation,

$$\sigma^2 = \sum_{i=0}^{n-1} \frac{(x_i - \mu)^2}{w},$$

where w is weighting and is «n-1» when weighting is set to sample and «n» when it is population.

Median

Description

Returns the median of the waveform for the entire or selected range.

Measurement Category

Statistics

Measurement Settings

Apply measurement on: Specifies the range for the measurement.

Two options exist for the measurement:

- Entire waveform
- Selected range of waveform

If the first option is selected, measurement is applied to the entire waveform, regardless of what is viewed, or selected with graph cursors.

If the second option is selected, measurement is applied only to the X range selected with the graph cursors.

Calculation

Median is the middle member's value of the waveform arranged from low value to high value. If the number of values is odd then median is calculated as the mean of the two middle values.

Histogram

Description

Returns the histogram of the waveform for the entire or selected range.

Measurement Category

Statistics

Measurement Settings

Intervals: Specifies the number of the intervals of the histogram plot.

Apply measurement on: Specifies the range for the measurement.

Two options exist for the measurement:

- Entire waveform
- Selected range of waveform

If the first option is selected, measurement is applied to the entire waveform, regardless of what is viewed, or selected with graph cursors.

If the second option is selected, measurement is applied only to the X range selected with the graph cursors.

Calculation

Histogram of the waveform is calculated by counting the number of times the specified interval occurs in the waveform.

Level Measurements

This group combines measurements which concern signal level calculations, such as amplitude calculation, high/low state level calculation, etc.

Amplitude

Description

Returns the amplitude of the waveform for the entire or selected range.

Measurement Category

Levels

Measurement Settings

Apply measurement on: Specifies the range for the measurement.

Two options exist for the measurement:

- Entire waveform
- Selected range of waveform

If the first option is selected, measurement is applied to the entire waveform, regardless of what is viewed, or selected with graph cursors.

If the second option is selected, measurement is applied only to the X range selected with the graph cursors.

Calculation

Amplitude is calculated as the difference between high state level and low state level.

Peak to Peak

Description

Returns peak to peak value of the waveform for the entire or selected range.

Measurement Category

Levels

Measurement Settings

Apply measurement on: Specifies the range for the measurement.

Two options exist for the measurement:

- Entire waveform
- Selected range of waveform

If the first option is selected, measurement is applied to the entire waveform, regardless of what is viewed, or selected with graph cursors.

If the second option is selected, measurement is applied only to the X range selected with the graph cursors.

Calculation

Peak to peak value is calculated as the difference between maximum and minimum values of the waveform.

High State Level

Description

Returns the high state level of the waveform for the entire or selected range.

Measurement Category

Levels

Measurement Settings

Apply measurement on: Specifies the range for the measurement.

Two options exist for the measurement:

- Entire waveform
- Selected range of waveform

If the first option is selected, measurement is applied to the entire waveform, regardless of what is viewed, or selected with graph cursors.

If the second option is selected, measurement is applied only to the X range selected with the graph cursors.

Calculation

High state level returns the level at which a pulse or transition waveform is defined to be in its highest state.

Low State Level

Description

Returns the low state level of the waveform for the entire or selected range.

Measurement Category

Levels

Measurement Settings

Apply measurement on: Specifies the range for the measurement.

Two options exist for the measurement:

- Entire waveform
- Selected range of waveform

If the first option is selected, measurement is applied to the entire waveform, regardless of what is viewed, or selected with graph cursors.

If the second option is selected, measurement is applied only to the X range selected with the graph cursors.

Calculation

Low state level returns the level at which a pulse or transition waveform is defined to be in its lowest state.

Average

Description

Returns average value of the waveform for the entire or selected range.

Measurement Category

Levels

Measurement Settings

Apply measurement on: Specifies the range for the measurement.

Two options exist for the measurement:

- Entire waveform
- Selected range of waveform

If the first option is selected, measurement is applied to the entire waveform, regardless of what is viewed, or selected with graph cursors.

If the second option is selected, measurement is applied only to the X range selected with the graph cursors.

Calculation

The average value of a waveform is calculated as follows:

$$avg = \frac{1}{n}\sum_{i=0}^{n-1} x_i$$

,

where n is the number of elements in input sequence X.

Filters

This group includes different types of filters. Filters can be applied to any type of signals in time domain. For correct results the selected waveform should be plotted vs. Time.

Bessel Filter

Description

Uses Bessel filter to filter the waveform in the entire range.

Measurement Category

Filters

Measurement Settings

Filter type: Specifies the filter type to be applied:

- Highpass
- Lowpass
- Bandpass
- Bandstop

Sampling frequency: Specifies the frequency in Hz at which the data will be sampled. The default value is 1.0 Hz.

High cutoff frequency: Specifies the high cutoff frequency of the filter. The default value is 0.45 Hz. If the filter type is lowpass high cutoff frequency is ignored.

Low cutoff frequency: Specifies the low cutoff frequency of the filter. The default value is 0.125 Hz. If the filter type is highpass the low cutoff frequency is ignored.

Order: Specifies the order of the filter. The higher the filter order, the bigger the roll-off.

Butterworth Filter

Description

Uses Butterworth filter to filter the waveform in the entire range.

Measurement Category

Filters

Measurement Settings

Filter type: Specifies the filter type to be applied:

- Highpass
- Lowpass
- Bandpass
- Bandstop

Sampling frequency: Specifies the frequency in Hz at which the data will be sampled. The default value is 1.0 Hz.

High cutoff frequency: Specifies the high cutoff frequency of the filter. The default value is 0.45 Hz. If the filter type is lowpass high cutoff frequency is ignored.

Low cutoff frequency: Specifies the low cutoff frequency of the filter. The default value is 0.125 Hz. If the filter type is highpass the low cutoff frequency is ignored.

Order: Specifies the order of the filter. The higher the filter order, the bigger the roll-off.

Chebyshev Filter

Description

Uses Chebyshev filter to filter the waveform in the entire range.

Measurement Category

Filters

Measurement Settings

Filter type: Specifies the filter type to be applied:

- Highpass
- Lowpass
- Bandpass
- Bandstop

Sampling frequency: Specifies the frequency in Hz at which the data will be sampled. The default value is 1.0 Hz.

High cutoff frequency: Specifies the high cutoff frequency of the filter. The default value is 0.45 Hz. If the filter type is lowpass high cutoff frequency is ignored.

Low cutoff frequency: Specifies the low cutoff frequency of the filter. The default value is 0.125 Hz. If the filter type is highpass the low cutoff frequency is ignored.

Ripple: Specifies the ripple in passband. Ripple should be expressed in decibels.

Order: Specifies the order of the filter. The higher the filter order the bigger the roll-off.

Inverse Chebyshev Filter

Description

Uses Inverse Chebyshev filter to filter the waveform in the entire range.

Measurement Category

Filters

Measurement Settings

Filter type: Specifies the filter type to be applied:

- Highpass
- Lowpass
- Bandpass
- Bandstop

Sampling frequency: Specifies the frequency in Hz at which the data will be sampled. The default value is 1.0 Hz.

High cutoff frequency: Specifies the high cutoff frequency of the filter. The default value is 0.45 Hz. If the filter type is lowpass high cutoff frequency is ignored.

Low cutoff frequency: Specifies the low cutoff frequency of the filter. The default value is 0.125 Hz. If the filter type is highpass the low cutoff frequency is ignored.

Attenuation: Specifies the attenuation of the stopband in dB. The default value is 60.0 dB.

Order: Specifies the order of the filter. The higher the filter order the bigger the roll-off.

Elliptic Filter

Description

Uses Elliptic filter to filter the waveform in the entire range.

Measurement Category

Filters

Measurement Settings

Filter type: Specifies the filter type to be applied:

- Highpass
- Lowpass
- Bandpass
- Bandstop

Sampling frequency: Specifies the frequency in Hz at which the data will be sampled. The default value is 1.0 Hz.

High cutoff frequency: Specifies the high cutoff frequency of the filter. The default value is 0.45 Hz. If the filter type is lowpass high cutoff frequency is ignored.

Low cutoff frequency: Specifies the low cutoff frequency of the filter. The default value is 0.125 Hz. If the filter type is highpass the low cutoff frequency is ignored.

Passband ripple: Specifies the ripple of the passband in dB. The default value is 1.0 dB.

Stopband attenuation: Specifies the attenuation of the stopband in dB. The default value is 60.0 dB.

Order: Specifies the order of the filter. The higher the filter order the bigger the roll-off.

Equiripple Bandpass Filter

Description

Uses FIR equiripple bandpass filter to filter the waveform in the entire range.

Measurement Category

Filters

Measurement Settings

Sampling frequency: Specifies the frequency in Hz at which the data will be sampled. The default value is 1.0 Hz.

No of Taps: Determines the total number of FIR coefficients.

Higher stop frequency: Specifies the higher frequency of the stop band. The default value is 0.4 Hz.

Lower stop frequency: Specifies the lower frequency of the stopband. The default value is 0.2 Hz.

Higher pass frequency: Specifies the higher frequency of passband. The default value is 0.35 Hz.

Lower pass frequency: Specifies the lower frequency of the passband. The default value is 0.25 Hz.

Equiripple Bandstop Filter

Description

Uses FIR equiripple bandstop filter to filter the waveform in the entire range.

Measurement Category

Filters

Measurement Settings

Sampling frequency: Specifies the frequency in Hz at which the data will be sampled. The default value is 1.0 Hz.

No of Taps: Determines the total number of FIR coefficients.

Higher stop frequency: Specifies the higher frequency of the stopband. The default value is 0.35 Hz.

Lower stop frequency: Specifies the lower frequency of the stopband. The default value is 0.25 Hz.

Higher pass frequency: Specifies the higher frequency of the passband. The default value is 0.4 Hz.

Lower pass frequency: Specifies the lower frequency of the passband. The default value is 0.2 Hz.

Equiripple Highpass Filter

Description

Uses FIR equi-ripple highpass filter to filter the waveform in the entire range.

Measurement Category

Filters

Measurement Settings

Sampling frequency: Specifies the frequency in Hz at which the data will be sampled. The default value is 1.0 Hz.

No of Taps: Determines the total number of FIR coefficients.

High frequency: Specifies the pass frequency of the filter. The default value is 0.3 Hz.

Stop frequency: Specifies the stop frequency of the filter. The default value is 0.2 Hz.

Equiripple Lowpass Filter

Description

Uses FIR equiripple lowpass filter to filter the waveform in the entire range.

Measurement Category

Filters

Measurement Settings

Sampling frequency: Specifies the frequency in Hz at which the data will be sampled. The default value is 1.0 Hz.

No of Taps: Determines the total number of FIR coefficients.

Pass frequency: Specifies the pass frequency of the filter. The default value is 0.2 Hz.

Stop frequency: Specifies the stop frequency of the filter. The default value is 0.3 Hz.

Median Filter

Description

Uses Median filter to filter the waveform in the entire range.

Measurement Category

Filters

Measurement Settings

Left rank: Specifies the number of elements to be used to compute the filter to the left side. The default value is 2.

Right rank: Specifies the number of elements to be used to compute the filter to the right side. The default value is -1.

Calculation

The Median Filter computes elements of the filtered signal using equation below.

$$Y_i = Median(J_i),\ where\ i = 0, 1, 2, \ldots, n-1$$

Y is the output sequence of the filtered signal. n is the number of elements in the input sequence X.

Ji is a subset of the input X, centered about the ith element of X, and the indexed elements outside the X range equal zero.

Ji can be described as:

$$J_i = \{x_{i-rl}, x_{i-rl+1}, K, x_{i-1}, x_i, x_{i+1}, K, x_{i+rr-1}, x_{i+rr}\},$$

where rl is the left rank and rr is the right rank.

FIR Windowed Filter

Description

Uses FIR windowed filter to filter the waveform in the entire range.

Measurement Category

Filters

Measurement Settings

Window: Specifies the type of the smoothing window.

Window parameter: Specifies parameters for different windows. For the Kaiser window specifies the beta parameter. For the Gaussian window specifies standard deviation. For the Dolph-Chebyshev window specifies the ratio "s" of the main lobe to the side lobe. For other types of windows' this setting is ignored.

Filter type: Specifies the filter type to be applied:

- Highpass
- Lowpass
- Bandpass
- Bandstop

No of Taps: Determines the total number of FIR coefficients.

Sampling frequency: Specifies the frequency in Hz at which the data will be sampled. The default value is 1.0 Hz.

High cutoff frequency: Specifies the high cutoff frequency of the filter. The default value is 0.45 Hz. If the filter type is lowpass high cutoff frequency is ignored.

Low cutoff frequency: Specifies the low cutoff frequency of the filter. The default value is 0.125 Hz. If the filter type is highpass the low cutoff frequency is ignored.

Order: Specifies the order of the filter. The higher the filter order, the bigger the roll-off.

Fitting

This group combines different methods for fitting data to known curves.

Linear Fit

Description

Returns the linear fit of the waveform for the entire or selected range. Linear fit is measured using the Least Square, Least Absolute Residual, or Bisquare method.

Slope and intercept are also calculated.

Measurement Category

Fitting

Measurement Settings

Tolerance: Specifies when to stop the iterative adjustment of slope and intercept when you use the Least Absolute Residual or Bisquare method. For the Least Absolute Residual method, if the relative difference between residues in two successive iterations is less than tolerance, it returns the resulting residue. For the Bisquare method, if any relative difference between slope and intercept in two successive iterations is less than tolerance, it returns the resulting slope and intercept.

If tolerance is less than or equal to 0, tolerance automatically sets to 0.0001.

Method: Specifies the fitting method:

- Least Square
- Least Absolute Residual
- Bisquare

Apply measurement on: Specifies the range for the measurement.

Two options exist for the measurement:

- Entire waveform
- Selected range of waveform

If the first option is selected, measurement is applied to the entire waveform, regardless of what is viewed, or selected with graph cursors.

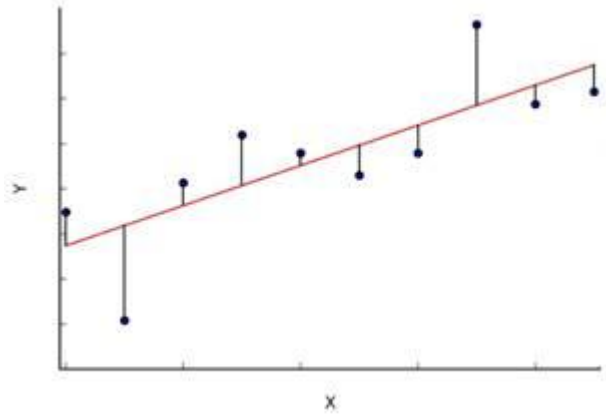
If the second option is selected, measurement is applied only to the X range selected with the graph cursors.

Calculation

Linear fit is calculated by the iterative general Least Square method and the Levenberg-Marquardt method to fit experimental data to a straight line of the general form described by the following equation:

$$f = ax + b$$

where x is the input sequence, a is slope, and b is intercept. It finds the values of a and b that best fit the observations (X,Y).



The Least Absolute Residual and Bisquare methods are robust fitting methods. Use these methods if outliers in the observations exist. In most cases, the Bisquare method is less sensitive to outliers than the Least Absolute Residual method.

When you use the Least Absolute Residual method, it finds the slope and intercept of the linear model by minimizing residue according to the following equation:

$$\frac{1}{N}\sum_{i=0}^{N-1} W_i |f_i - y_i|$$

Exponential Fit

Description

Returns the exponential fit of the waveform for the entire or selected range. Exponential fit uses the Least Square, Least Absolute Residual, or Bisquare method.

Amplitude and damping are also calculated.

Measurement Category

Fitting

Measurement Settings

Tolerance: Specifies when to stop the iterative adjustment of amplitude, damping and offset. For the Least Square and Least Absolute Residual methods, if the relative difference between residues in two successive iterations is less than tolerance, it returns the resulting residue. For the Bisquare method, if any relative difference between amplitude, damping, and offset in two successive iterations is less than tolerance, it returns the resulting amplitude, damping, and offset.

If tolerance is less than or equal to 0, tolerance automatically sets to 0.0001.

Method: Specifies the fitting method:

- Least Square
- Least Absolute Residual
- Bisquare

Apply measurement on: Specifies the range for the measurement.

Two options exist for the measurement:

- Entire waveform
- Selected range of waveform

If the first option is selected, measurement is applied to the entire waveform, regardless of what is viewed, or selected with graph cursors.

If the second option is selected, measurement is applied only to the X range selected with the graph cursors.

Calculation

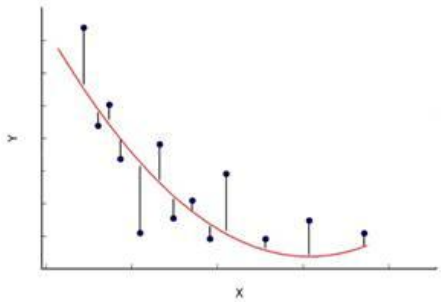
Exponential fit uses the iterative general Least Square method and the Levenberg-Marquardt method to fit data to an experimental curve of the general form described by the following equation:

$$f = ae^{bx} + c$$

where x is the input sequence, a is amplitude, b is damping, and c is offset. It finds the values of a, b and c that best fit the observations (X,Y).

The following equation specifically describes the exponential curve resulting from the exponential fit algorithm:

$$y[i] = ae^{bx[i]} + c$$



When you use the Least Square method, it finds the amplitude, damping, and offset of the exponential model by minimizing the residue according to the following equation:

$$\frac{1}{N}\sum_{i=0}^{N-1} W_i(f_i - y_i)^2$$

The Least Absolute Residual and Bisquare methods are robust fitting methods. Use these methods if outliers in the observations exist. In most cases, the Bisquare method is less sensitive to outliers than the Least Absolute Residual method.

When you use the Least Absolute Residual method, it finds the amplitude, damping and offset of the exponential model by minimizing residue according to the following equation:

$$\frac{1}{N}\sum_{i=0}^{N-1} W_i |f_i - y_i|$$

Power Fit

Description

Returns the power fit of the waveform for the entire or selected range. Power fit uses the Least Square, Least Absolute Residual, or Bisquare method.

Amplitude and power are also calculated.

Measurement Category

Fitting

Measurement Settings

Tolerance: Specifies when to stop the iterative adjustment of amplitude, power and offset. For the Least Square and Least Absolute Residual methods, if the relative difference between residues in two successive iterations is less than tolerance, it returns the resulting residue. For the Bisquare method, if any relative difference between amplitude, power, and offset in two successive iterations is less than tolerance, it returns the resulting amplitude, power, and offset.

If tolerance is less than or equal to 0, tolerance automatically sets to 0.0001.

Method: Specifies the fitting method:

- Least Square
- Least Absolute Residual
- Bisquare

Apply measurement on: Specifies the range for the measurement.

Two options exist for the measurement:

- Entire waveform
- Selected range of waveform

If the first option is selected, measurement is applied to the entire waveform, regardless of what is viewed, or selected with graph cursors.

If the second option is selected, measurement is applied only to the X range selected with the graph cursors.

Calculation

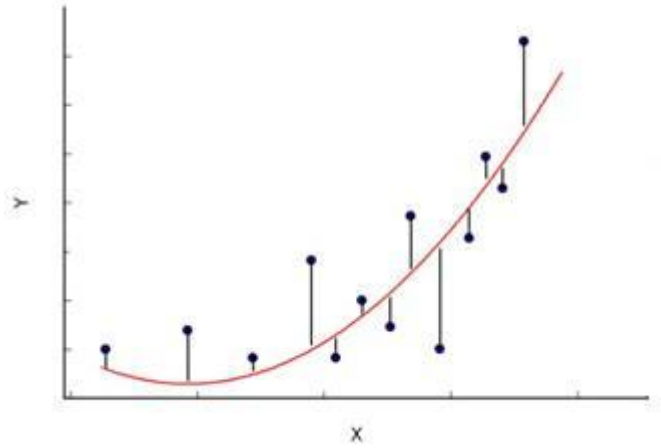
Power fit uses the iterative general Least Square method and the Levenberg-Marquardt method to fit data to an experimental curve of the general form described by the following equation:

$$f = ax^b + c$$

where x is the input sequence, a is amplitude, b is power, and c is offset. It finds the values of a, b and c that best fit the observations (X,Y).

The following equation specifically describes the power function resulting from the general power fit algorithm:

$$y[i] = a\left(x[i]^b\right) + c$$



When you use the Least Square method, it finds the amplitude, power, and offset of the power model by minimizing the residue according to the following equation:

$$\frac{1}{N}\sum_{i=0}^{N-1} W_i(f_i - y_i)^2$$

The Least Absolute Residual and Bisquare methods are robust fitting methods. Use these methods if outliers in the observations exist. In most cases, the Bisquare method is less sensitive to outliers than the Least Absolute Residual method.

When you use the Least Absolute Residual method, it finds the amplitude, power and offset of the power model by minimizing residue according to the following equation:

$$\frac{1}{N}\sum_{i=0}^{N-1} W_i|f_i - y_i|$$

Logarithmic Fit

Description

Returns the logarithmic fit of the waveform for the entire or selected range. Logarithmic fit uses the Least Square, Least Absolute Residual, or Bisquare method.

Amplitude and scale are also calculated.

Measurement Category

Fitting

Measurement Settings

Base: Specifies the base of the logarithm.

Tolerance: Specifies when to stop the iterative adjustment of amplitude and scale. For the Least Square and Least Absolute Residual methods, if the relative difference between residues in two successive iterations is less than tolerance, it returns the resulting residue. For the Bisquare method, if any relative difference between amplitude and scale in two successive iterations is less than tolerance, it returns the resulting amplitude and scale.

If tolerance is less than or equal to 0, tolerance automatically sets to 0.0001.

Method: Specifies the fitting method:

- Least Square
- Least Absolute Residual
- Bisquare

Apply measurement on: Specifies the range for the measurement.

Two options exist for the measurement:

- Entire waveform
- Selected range of waveform

If the first option is selected, measurement is applied to the entire waveform, regardless of what is viewed, or selected with graph cursors.

If the second option is selected, measurement is applied only to the X range selected with the graph cursors.

Calculation

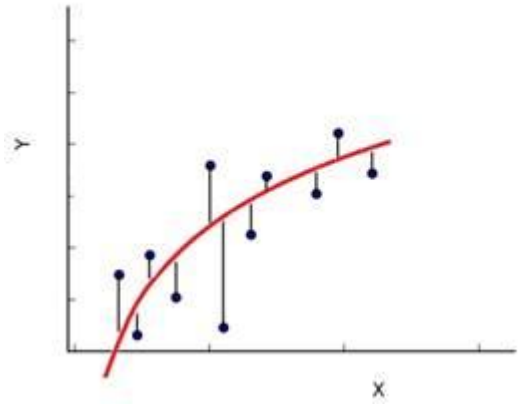
Logarithmic fit uses the iterative general Least Square method and the Levenberg-Marquardt method to fit data to a logarithmic function of the general form described by the following equation:

$$f = a \log_c bx$$

where x is the input sequence, c is base, a is amplitude, and b is scale. It finds the values of a and b that best fit the observations (X,Y).

The following equation describes the logarithm function resulting from the logarithm fit algorithm:

$$y[i] = a \log_c bx[i]$$



When you use the Least Square method, it finds the amplitude and scale of the logarithmic model by minimizing the residue according to the following equation:

$$\frac{1}{N}\sum_{i=0}^{N-1} W_i(f_i - y_i)^2$$

The Least Absolute Residual and Bisquare methods are robust fitting methods. Use these methods if outliers in the observations exist. In most cases, the Bisquare method is less sensitive to outliers than the Least Absolute Residual method.

When you use the Least Absolute Residual method, it finds the amplitude and scale of the logarithmic model by minimizing residue according to the following equation:

$$\frac{1}{N}\sum_{i=0}^{N-1} W_i|f_i - y_i|$$

Gaussian Peak Fit

Description

Returns the Gaussian peak fit of the waveform for the entire or selected range. Gaussian peak fit uses the Least Square, Least Absolute Residual, or Bisquare method.

Amplitude, center, standard deviation and offset are also calculated.

Measurement Category

Fitting

Measurement Settings

Initial amplitude: Specifies initial guess of amplitude.

Initial center: Specifies initial guess of center.

Initial Standard deviation: Specifies initial guess of standard deviation.

Initial offset: Specifies initial guess of the offset it returns.

Tolerance: Specifies when to stop the iterative adjustment of amplitude, center, standard deviation, and offset. For the Least Square and Least Absolute Residual methods, if the relative difference between residues in two successive iterations is less than tolerance, it returns the resulting residue. For the Bisquare method, if any relative difference between amplitude, center, standard deviation, or offset in two successive iterations is less than tolerance, it returns the resulting amplitude, center, standard deviation, and offset.

If tolerance is less than or equal to 0, tolerance automatically sets to 0.0001.

Method: Specifies the fitting method:

- Least Square
- Least Absolute Residual
- Bisquare

Apply measurement on: Specifies the range for the measurement.

Two options exist for the measurement:

- Entire waveform
- Selected range of waveform

If the first option is selected, measurement is applied to the entire waveform, regardless of what is viewed, or selected with graph cursors.

If the second option is selected, measurement is applied only to the X range selected with the graph cursors.

Calculation

Gaussian peak fit uses the iterative general Least Square method and the Levenberg-Marquardt method to fit data to a Gaussian curve in a form described by the following equation:

$$f = a * exp\left(-\frac{(x-\mu)^2}{2\sigma^2}\right) + c$$

where x is the input sequence,

a is amplitude,

μ is center,

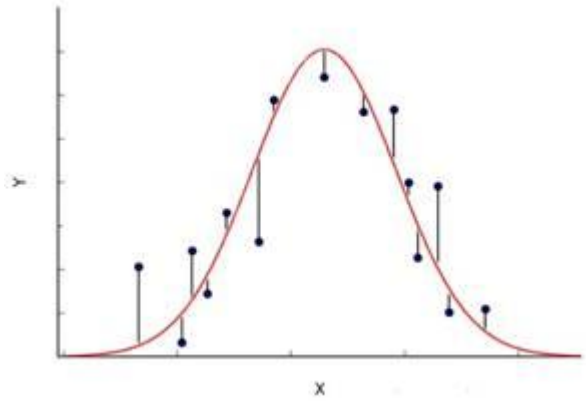
σ is standard deviation,

c is offset.

It finds the values of amplitude, center, standard deviation and offset that best fit the observations (X,Y).

The following equation specifically describes the Gaussian curve resulting from the Gaussian fit algorithm:

$$y[i] = a * exp\left(-\frac{(x[i]-\mu)^2}{2\sigma^2}\right) + c$$



When you use the Least Square method, it finds the amplitude, center, standard deviation and offset of the Gaussian model by minimizing the residue according to the following equation:

$$\frac{1}{N}\sum_{i=0}^{N-1} W_i(f_i - y_i)^2$$

The Least Absolute Residual and Bisquare methods are robust fitting methods. Use these methods if outliers in the observations exist. In most cases, the Bisquare method is less sensitive to outliers than the Least Absolute Residual method.

When you use the Least Absolute Residual method, it finds the amplitude, center, standard deviation and offset of the Gaussian model by minimizing residue according to the following equation:

$$\frac{1}{N}\sum_{i=0}^{N-1} W_i|f_i - y_i|$$

Polynomial Fit

Description

Returns the Polynomial fit of the waveform for the entire or selected range. Polynomial fit uses the Least Square, Least Absolute Residual, or Bisquare method.

Polynomial Coefficients are also calculated.

Measurement Category

Fitting

Measurement Settings

Polynomial order: Specifies the order of the polynomial that fits to the data set. Polynomial order must be greater than or equal to 0. In real applications, polynomial order is less than 10. Polynomial order can't be greater than 25. The default is 2.

Algorithm: Specifies the algorithm uses to compute Best Polynomial Fit. Use SVD for Rank Deficient H if all other algorithms are unsuccessful.

- SVD
- Givens
- Givens2
- Householder
- LU Decomposition
- Cholesky
- SVD for Rank Deficient H

Tolerance: Specifies when to stop the iterative adjustment of Polynomial Coefficients when you use the Least Absolute Residual or Bisquare methods. For the Least Absolute Residual method, if the relative difference between residue in two successive iterations is less than tolerance, it returns the resulting Polynomial Coefficients. For the Bisquare method, if any relative difference between Polynomial Coefficients in two successive iterations is less than tolerance, it returns the resulting Polynomial Coefficients.

If tolerance is less than or equal to 0, tolerance automatically sets to 0.0001.

Method: Specifies the fitting method:

- Least Square
- Least Absolute Residual
- Bisquare

Apply measurement on: Specifies the range for the measurement.

Two options exist for the measurement:

- Entire waveform

- Selected range of waveform

If the first option is selected, measurement is applied to the entire waveform, regardless of what is viewed, or selected with graph cursors.

If the second option is selected, measurement is applied only to the X range selected with the graph cursors.

Calculation

It fits data to a polynomial function of the general form described by the following equation:

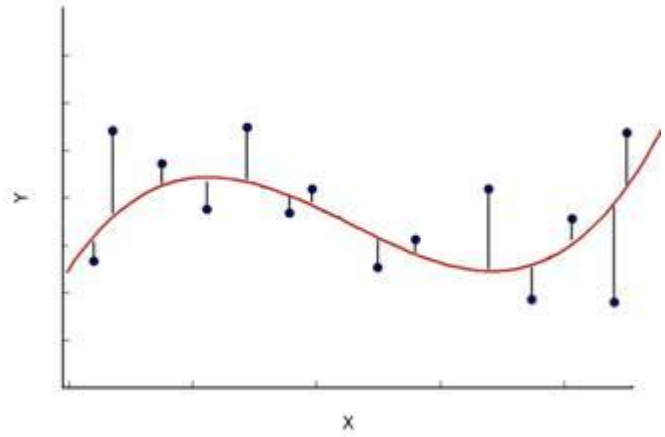
$$f_i = \sum_{j=1}^{m} a_j x_i^j$$

,

where f represents the output sequence Best Polynomial Fit, x is the input sequence, "a" represents Polynomial Coefficients, and m represents polynomial order. It finds the value of a that best fits the observations (X, Y).

The following equation specifically describes the polynomial curve resulting from the general polynomial fit algorithm:

$$y_i = \sum_{j=1}^{m} a_j (x[i])^j$$



When you use the Least Square method, it finds the Polynomial Coefficient of polynomial model by minimizing the residue according to the following equation:

$$\frac{1}{N} \sum_{i=0}^{N-1} W_i (f_i - y_i)^2$$

The Least Absolute Residual and Bisquare methods are robust fitting methods. Use these methods if outliers in the observations exist. In most cases, the Bisquare method is less sensitive to outliers than the Least Absolute Residual method.

When you use the Least Absolute Residual method, it finds Polynomial Coefficient of polynomial model by minimizing residue according to the following equation:

$$\frac{1}{N}\sum_{i=0}^{N-1} W_i|f_i - y_i|$$

Cubic Spline Fit

Description

Uses cubic spline fitting to smooth the waveform for the entire or selected range.

Measurement Category

Fitting

Measurement Settings

Balance parameter: Specifies the balance between the smoothness of the cubic spline fit and the accuracy with which it fits the observations. Balance parameter must fall within the range [0, 1]. If balance parameter is 0, the cubic spline fit is equivalent to a linear fit. If balance parameter is 1, the cubic spline fit interpolates between the data points.

If balance parameter is out of the range [0, 1], it calculates an appropriate value for balance parameter automatically.

Method: Specifies the fitting method:

- Least Square
- Least Absolute Residual
- Bisquare

Apply measurement on: Specifies the range for the measurement.

Two options exist for the measurement:

- Entire waveform
- Selected range of waveform

If the first option is selected, measurement is applied to the entire waveform, regardless of what is viewed, or selected with graph cursors.

If the second option is selected, measurement is applied only to the X range selected with the graph cursors.

Calculation

Cubic fit fits the observations (X, Y) by minimizing the following function:

$$p\sum_{i=0}^{n-1}\left(y_i - f(x_i)\right)^2 + (1-p)\int_{x_0}^{x_{n-1}} \lambda(x)\left(f''(x)\right)^2 dx$$

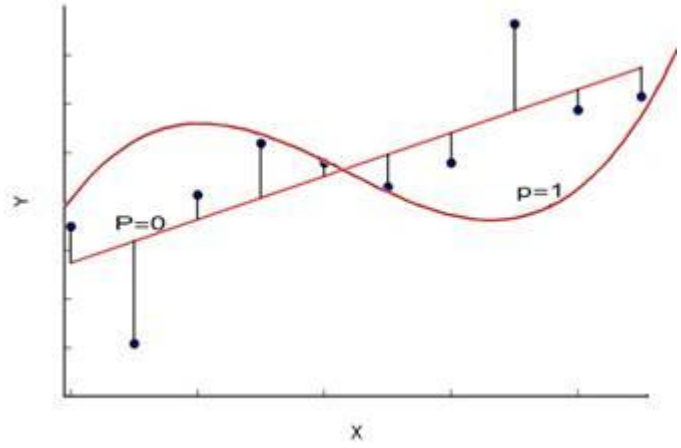
where p is the balance parameter. yi is the i-th element of Y. xi is the i-th element of X. f''(x) is the second-order derivative of the f(x) cubic spline function.

λ(x) is the piecewise constant function

$$\lambda(x) = \lambda_i,\ x_i \le x \le x_{i+1},\qquad for\ i = 0, 1, \ldots, n-2$$

Where λ_i is the i-th element of smoothness.

If p = 0, the fitted model is equivalent to a linear model. If p = 1, the fitting is equivalent to cubic spline interpolation. p must fall in the range [0, 1] to make the fitted curve both close to the observations and smooth. The closer p is to 0, the smoother the fitted curve. The closer p is to 1, the closer the fitted curve is to the observations.



Transforms

This group includes different transforms for the waveforms, such as Fast Fourier transform, Walsh-Hadamard transform, Fast Hilbert transform, etc.

Fast Fourier Transform

Description

Calculates Fast Fourier Transform (FFT) of the signal. FFT computes the discrete Fourier transform of the signal. FFT can be computed for the entire or selected range of the signal.

Measurement Category

Transforms

Measurement Settings

Shift: Specifies whether DC component is at the center of FFT {signal}. If Shift is ON, DC component will be at the center of FFT {signal}.

FFT Size: Specifies the length of the FFT be performed. If FFT size is less than the number of elements in the signal, only first elements (with number equal to FFT size) are used to perform the FFT. If FFT size is greater than the number of elements in the signal, zeros are added to the end of the signal.

Apply measurement on: Specifies the range for the measurement.

Two options exist for the measurement:

- Entire waveform
- Selected range of waveform

If the first option is selected, measurement is applied to the entire waveform, regardless of what is viewed, or selected with graph cursors.

If the second option is selected, measurement is applied only to the X range selected with the graph cursors.

Calculation

FFT computes the discrete Fourier transform (DFT) of the signal with fast Fourier transform algorithm. Discrete Fourier transform is defined by the following equation:

$Y_k = \sum_{n=0}^{N-1} x_n \cdot e^{-i2\pi kn/N}$ for n=0, 1, 2, …, N-1 ,

where x is the input signal (sequence), N is the number of elements in input sequence, and Y is the result of transform.

Frequency spacing (resolution) between Y components is:

$\Delta f = \frac{f_s}{N}$,

where f_s is the sampling frequency.

Fast Hilbert Transform

Description

Calculates Fast Hilbert Transform of the signal. Fast Hilbert Transform can be computed for the entire or selected range of the signal.

Measurement Category

Transforms

Measurement Settings

Apply measurement on: Specifies the range for the measurement.

Two options exist for the measurement:

- Entire waveform
- Selected range of waveform

If the first option is selected, measurement is applied to the entire waveform, regardless of what is viewed, or selected with graph cursors. If the second option is selected, measurement is applied only to the X range selected with the graph cursors.

Calculation

The Hilbert transform of a function is given as:

$$h(t) = \frac{1}{\pi}\int_{-\infty}^{\infty}\frac{x(\tau)}{t-\tau}d\tau$$

The Hilbert transform is a multiplier operator. The symbol of H is

$$\sigma H(\omega) = -i\,sgn(\omega),$$

where sgn is the signum function.

Fourier transform of the Hilbert transform of a function x(t) is:

$$h(t) \Leftrightarrow H(f) = -i\,sgn(f)X(f)$$

where $x(t) \Leftrightarrow X(f)$ is a Fourier transform pair and

$$sgn(f) = \begin{cases} 1 & f > 0 \\ 0 & f = 0 \\ -1 & f < 0 \end{cases}$$

Fast Hilbert transform performs the discrete implementation of the Hilbert transform with the aid of the fast Fourier transform routines based upon the $h(t) \Leftrightarrow H(f)$ Fourier transform pair.

Inverse Fast Hilbert Transform

Description

Calculates the inverse fast Hilbert Transform of the signal. Inverse Fast Hilbert Transform can be computed for the entire or selected range of the signal.

Measurement Category

Transforms

Measurement Settings

Apply measurement on: Specifies the range for the measurement.

Two options exist for the measurement:

- Entire waveform
- Selected range of waveform

If the first option is selected, measurement is applied to the entire waveform, regardless of what is viewed, or selected with graph cursors.

If the second option is selected, measurement is applied only to the X range selected with the graph cursors.

Calculation

The inverse Hilbert transform of a function h(t) is given as:

$$x(t) = H^{-1} \cdot \{h(t)\} = -\frac{1}{\pi}\int_{-\infty}^{\infty}\frac{h(\tau)}{t-\tau}d\tau$$

By using Hilbert transform inverse Hilbert transform can be computed by negating the forward Hilbert transform:

$$x(t) = H^{-1} \cdot \{h(t)\} = -H\{h(t)\}$$

Inverse Fast Hilbert transform performs the discrete implementation of the inverse Hilbert transform with the aid of the Hilbert transform.

Fast Hartley Transform

Description

Calculates Fast Hartley Transform (FHT) of the signal. For proper calculation of fast Hartley transform number of elements in the input sequence should be a valid power of two. Fast Hartley transform can be computed for the entire or selected range of the signal.

Measurement Category

Transforms

Measurement Settings

Apply measurement on: Specifies the range for the measurement.

Two options exist for the measurement:

- Entire waveform
- Selected range of waveform

If the first option is selected, measurement is applied to the entire waveform, regardless of what is viewed, or selected with graph cursors.

If the second option is selected, measurement is applied only to the X range selected with the graph cursors.

Calculation

The Hartley transform of a function x(t) is given as:

$$X(f) = \int_{-\infty}^{\infty} x(t) cas(2\pi f t) d\tau$$

where $cas(x) = \cos(x) + \sin(x)$.

The Hartley transform maps real-valued sequences into real-valued frequency domain sequences.

Fast Hartley transform is obtained through the discrete implementation of the Hartley integral:

$$Y_k = \sum_{i=0}^{n-1} X_i cas(\frac{2\pi ik}{n})$$

for k=1,2,…. n-1, where n is the number of X elements.

Inverse Fast Hartley Transform

Description

Calculates Inverse Fast Hartley Transform (inverse FHT) of the signal. For proper calculation of inverse fast Hartley transform number of elements in the input sequence should be a valid power of two. Inverse fast Hartley transform can be computed for the entire or selected range of the signal.

Measurement Category

Transforms

Measurement Settings

Apply measurement on: Specifies the range for the measurement.

Two options exist for the measurement:

- Entire waveform
- Selected range of waveform

If the first option is selected, measurement is applied to the entire waveform, regardless of what is viewed, or selected with graph cursors.

If the second option is selected, measurement is applied only to the X range selected with the graph cursors.

Calculation

The inverse Hartley transform of a function x(t) is given as:

$$x(t) = \int_{-\infty}^{\infty} X(f) cas(2\pi f t) df$$

where $cas(x) = \cos(x) + \sin(x)$.

The inverse Hartley transform maps real-valued frequency domain sequences into real-valued sequences.

Inverse fast Hartley transform is obtained through the discrete implementation of the inverse Hartley integral:

$$Y_k = \frac{1}{n} \sum_{i=0}^{n-1} X_i cas(\frac{2\pi i k}{n})$$

for k=1,2,…. n-1, where n is the number of X elements.

Walsh Hadamard Transform

Description

Calculates the real Walsh Hadamard Transform of the signal. Walsh Hadamard transform can be computed for the entire or selected range of the signal.

Measurement Category

Transforms

Measurement Settings

Apply measurement on: Specifies the range for the measurement.

Two options exist for the measurement:

- Entire waveform
- Selected range of waveform

If the first option is selected, measurement is applied to the entire waveform, regardless of what is viewed, or selected with graph cursors.

If the second option is selected, measurement is applied only to the X range selected with the graph cursors.

Calculation

The Walsh Hadamard transform performs an orthogonal, symmetric, involutional, linear operation on 2^m real numbers. The Walsh Hadamard transform is based on an orthogonal system consisting of functions of only two elements -1 and 1.

If WHn and WHn+1 denote the Walsh Hadamard matrices of dimension 2^n and 2^(n+1) respectively, then:

$$WH_{n+1} = \begin{bmatrix} WH_n & WH_n \\ WH_n & -WH_n \end{bmatrix}$$

where –WHn is meant in the element wise sense.

Inverse Walsh Hadamard Transform

Description

Calculates the inverse of real Walsh Hadamard Transform of the signal. Inverse Walsh Hadamard transform can be computed for the entire or selected range of the signal.

Measurement Category

Transforms

Measurement Settings

Apply measurement on: Specifies the range for the measurement.

Two options exist for the measurement:

- Entire waveform
- Selected range of waveform

If the first option is selected, measurement is applied to the entire waveform, regardless of what is viewed, or selected with graph cursors.

If the second option is selected, measurement is applied only to the X range selected with the graph cursors.

Calculation

The inverse Walsh Hadamard transform is calculated according to the following formula:

$$WHI\{X\} = \frac{1}{n} WH\{X\}$$

where n is the length of the signal X, WHI{X} is the inverse Walsh Hadamard transform and WH{X} is the Walsh Hadamard transform of the signal X.

Laplace Transform

Description

Calculates Laplace Transform of the signal. Laplace Transform can be computed for the entire or selected range of the signal.

Measurement Category

Transforms

Measurement Settings

End: Specifies instant in time of the last sample. The entire sample interval is between 0 and the specified End.

Apply measurement on: Specifies the range for the measurement.

Two options exist for the measurement:

- Entire waveform
- Selected range of waveform

If the first option is selected, measurement is applied to the entire waveform, regardless of what is viewed, or selected with graph cursors.

If the second option is selected, measurement is applied only to the X range selected with the graph cursors.

Calculation

The real Laplace transform of a real signal x(s) is given as:

$$X(s) = \int_0^{\infty} x(t) e^{-st} dt$$

for S>=0 and S real. x(t) is defined for all t>=0.

Mathematics

This group combines mathematical calculations, such as integral and derivative.

Integral

Description

Returns the integral of the waveform for entire or selected range. The calculation of waveforms with non-monotonic X axis can return incorrect results.

Measurement Category

Mathematics

Measurement Settings

Apply measurement on: Specifies the range for the measurement.

Two options exist for the measurement:

- Entire waveform
- Selected range of waveform

If the first option is selected, measurement is applied to the entire waveform, regardless of what is viewed, or selected with graph cursors.

If the second option is selected, measurement is applied only to the X range selected with the graph cursors.

Calculation

Integral of the curve in the selected range is the sum of the areas of rectangles, which are formed by pairs of two neighboring x coordinates and y value corresponding to the righteous x coordinate of that pair.

Derivative

Description

Returns the derivative of the waveform for entire or selected range.

Measurement Category

Mathematics

Measurement Settings

Method: Specifies the method of the calculation:

- 2nd order
- 4th order
- Forward
- Backward

dt: Specifies the time interval of the waveform. Commonly dt is 1/dfs, where dfs is the sampling frequency.

Apply measurement on: Specifies the range for the measurement.

Two options exist for the measurement:

- Entire waveform
- Selected range of waveform

If the first option is selected, measurement is applied to the entire waveform, regardless of what is viewed, or selected with graph cursors.

If the second option is selected, measurement is applied only to the X range selected with the graph cursors.

Calculation

The formula of the derivatives for four different ways of calculations is shown below:

- 2nd order

$$f(x_i) = \frac{1}{2dt}(x_{i+1} - x_{i-1})$$

- 4th order

$$f(x_i) = \frac{1}{12dt}(x_{i-2} - x_{i+2} + 8x_{i+1} - 8x_{i-1})$$

- Forward

$$f(x_i) = \frac{1}{dt}(x_{i+1} - x_i)$$

- Backward

$$f(x_i) = \frac{1}{dt}(x_i - x_{i-1})$$

Spectral Analysis

Measurements in this group perform different spectral analysis. These measurements should be applied to the waveform in time domain.

Auto Power Spectrum

Description

Returns the auto power spectrum of the waveform for the entire or selected range.

Measurement Category

Spectral Analysis

Measurement Settings

dt: Specifies the time interval of the waveform. Commonly dt is $^1/_{df_s}$, where f_s is the sampling frequency.

Apply measurement on: Specifies the range for the measurement.

Two options exist for the measurement:

- Entire waveform
- Selected range of waveform

If the first option is selected, measurement is applied to the entire waveform, regardless of what is viewed, or selected with graph cursors.

If the second option is selected, measurement is applied only to the X range selected with the graph cursors.

Calculation

Calculates the auto spectrum of the waveform using the fast Fourier transformation of the signal and complex conjugate of FFT using formula:

$$S = \frac{FFT(X) \times FFT^*(X)}{n^2}$$,

where n is the number of points in the signal, FFT is the fast Fourier transformation and «*» indicates the complex conjugate.

Power Spectrum

Description

Returns the power spectrum of the waveform for the entire or selected range.

Measurement Category

Spectral Analysis

Measurement Settings

dt: Specifies the time interval of the waveform. Commonly dt is $^1/_{df_s}$, where f_s is the sampling frequency.

Apply measurement on: Specifies the range for the measurement.

Two options exist for the measurement:

- Entire waveform
- Selected range of waveform

If the first option is selected, measurement is applied to the entire waveform, regardless of what is viewed, or selected with graph cursors.

If the second option is selected, measurement is applied only to the X range selected with the graph cursors.

Calculation

Calculates the spectrum of the waveform using the fast Fourier transformation of the input signal with following formula:

$$S = \frac{|F(X)|^2}{n^2}$$,

where n is the number of points in the input signal, and F(X) is the Fourier transform of the X function.

Phase Spectrum

Description

Returns the phase spectrum of the waveform for the entire or selected range.

Measurement Category

Spectral Analysis

Measurement Settings

dt: Specifies the time interval of the waveform. Commonly dt is $1/df_s$, where f_s is the sampling frequency.

Unwrap phase: Enables the option of phase unwrapping. The default value is ON.

Apply measurement on: Specifies the range for the measurement.

Two options exist for the measurement:

- Entire waveform
- Selected range of waveform

If the first option is selected, measurement is applied to the entire waveform, regardless of what is viewed, or selected with graph cursors.

If the second option is selected, measurement is applied only to the X range selected with the graph cursors.

Calculation

Phase spectrum is calculated by taking the exponential part of the calculated one sided spectrum.

Cross Power Spectrum

Description

Returns the power spectrum of the two crossed waveforms for entire or selected range.

Measurement Category

Spectral Analysis

Measurement Settings

dt: Specifies the time interval of the waveform. Commonly dt is $1/df_s$, where f_s is the sampling frequency.

Apply measurement on: Specifies the range for the measurement.

Two options exist for the measurement:

- Entire waveform
- Selected range of waveform

If the first option is selected, measurement is applied to the entire waveform, regardless of what is viewed, or selected with graph cursors.

If the second option is selected, measurement is applied only to the X range selected with the graph cursors.

Calculation

Calculates the spectrum of the waveform generated by crossing two input signals. The spectrum is calculated by the following formula:

$$S = \frac{FFT(X) \times FFT^*(Y)}{N^2},$$

where N is the number of points in the input signal. If the input signals are of different lengths then the program will fill the shorter data with zeroes to make the two signals the same length. In that case N is the number of points after the shorter signal has been filled with zeroes.

Amplitude Spectrum

Description

Returns the magnitude of the power spectrum of the waveform for the entire or selected range.

Measurement Category

Spectral Analysis

Measurement Settings

dt: Specifies the time interval of the waveform. Commonly dt is $1/df_s$, where f_s is the sampling frequency.

Unwrap phase: Enables the option of phase unwrapping. The default value is ON.

Apply measurement on: Specifies the range for the measurement.

Two options exist for the measurement:

- Entire waveform
- Selected range of waveform

If the first option is selected, measurement is applied to the entire waveform, regardless of what is viewed, or selected with graph cursors.

If the second option is selected, measurement is applied only to the X range selected with the graph cursors.

Calculation

Magnitude of the power spectrum is calculated by taking the real part of the power spectrum.

Time Domain Measurements

Measurements in this group are for calculations which refer to time domain. Time domain measurements include transition, period, frequency calculation, etc.

For correct results, these measurements should be applied on the waveform for which Time is selected as X axis.

Period

Description

Measures Period of the periodic waveform between adjacent reference level crossings in the same direction in the entire or selected range. Period can be measured for all or selected pulses.

Measurement Category

Time Domain

Measurement Settings

Calculate for: Specifies pulses for which measurement should be done.

Two options exist for the measurement:

- All Pulses
- Pulse Number

If the first option is selected, period is calculated for all pulses. If the second option is selected, period is calculated for the selected pulse.

Reference Level (%): Specifies the middle reference level of the waveform in percent, required to determine period. Percentage is defined relative to the topline levels.

Apply measurement on: Specifies the range for the measurement.

Two options exist for the measurement:

- Entire waveform
- Selected range of waveform

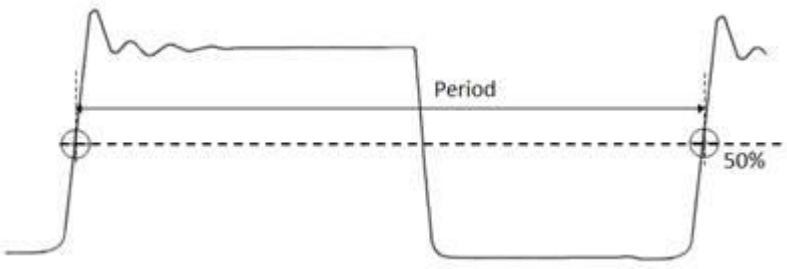
If the first option is selected, measurement is applied to the entire waveform, regardless of what is viewed, or selected with graph cursors.

If the second option is selected, measurement is applied only to the X range selected with the graph cursors.

Calculation

Period is calculated by finding two consecutive edges of the waveform with the same polarity. Period is the difference in time between reference crossings of the two adjacent edges.

Example of the period calculation is shown with 50% reference level.



Frequency

Description

Measures Frequency of the periodic waveform between adjacent reference level crossings in the same direction in the entire or selected range. Frequency can be measured for all or selected pulses.

Measurement Category

Time Domain

Measurement Settings

Calculate for: Specifies pulses for which measurement should be done.

Two options exist for the measurement:

- All Pulses
- Pulse Number

If the first option is selected, frequency is calculated for all pulses. If the second option is selected, frequency is calculated for the selected pulse.

Reference Level (%): Specifies the middle reference level of the waveform in percent, required to determine frequency. Percentage is defined relative to the topline levels.

Apply measurement on: Specifies the range for the measurement.

Two options exist for the measurement:

- Entire waveform
- Selected range of waveform

If the first option is selected, measurement is applied to the entire waveform, regardless of what is viewed, or selected with graph cursors.

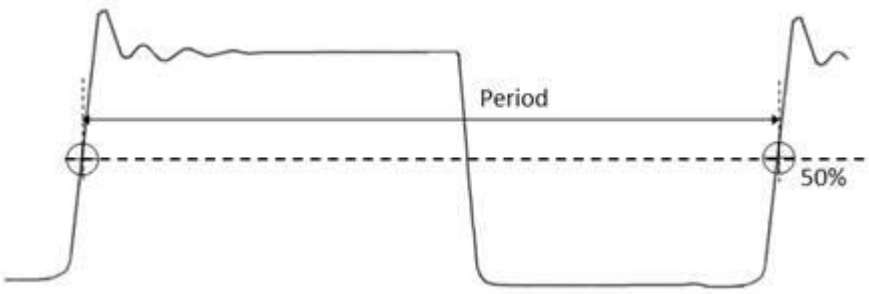
If the second option is selected, measurement is applied only to the X range selected with the graph cursors.

Calculation

Frequency is calculated as the reciprocal of the period. Period is calculated by finding two consecutive edges of the waveform with the same polarity. Period is the difference in time between reference crossings of the two adjacent edges.

$$Frequency = \frac{1}{Period}$$

Example of frequency calculation is shown with 50% reference level.



Duty Cycle

Description

Measures Duty Cycle of the periodic waveform in the entire or selected range. Duty Cycle can be measured for all or selected pulses.

Measurement Category

Time Domain

Measurement Settings

Calculate for: Specifies pulses for which measurement should be done.

Two options exist for the measurement:

- All Pulses
- Pulse Number

If the first option is selected, duty cycle is calculated for all pulses. If the second option is selected, duty cycle is calculated for the selected pulse.

Reference Level (%): Specifies the middle reference level of the waveform in percent, required to determine duty cycle. Percentage is defined relative to the topline levels.

Apply measurement on: Specifies the range for the measurement.

Two options exist for the measurement:

- Entire waveform
- Selected range of waveform

If the first option is selected, measurement is applied to the entire waveform, regardless of what is viewed, or selected with graph cursors.

If the second option is selected, measurement is applied only to the X range selected with the graph cursors.

Calculation

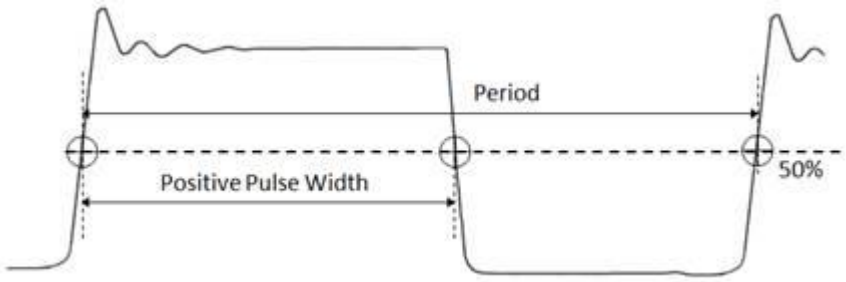
Duty cycle is calculated as the ration of the positive pulse width to the period of the waveform.

Period is calculated by finding two consecutive edges of the waveform with the same polarity. Period is the difference in time between reference crossings of the two adjacent edges.

Positive pulse width is calculated as the difference in time between reference level crossing of a rising edge and reference level crossing of the next falling edge of the waveform.

$$Duty\ Cycle = \frac{Positive\ Pulse\ Width}{Period}$$

Example of the duty cycle calculation is shown with 50% reference level.



Positive Pulse Width

Description

Measures duration of the positive pulse of the waveform for the entire or selected range. Pulse width is the time difference between reference level crossings of the two adjacent edges of the pulse. Pulse width can be measured for all or selected pulses.

Measurement Category

Time Domain

Measurement Settings

Calculate for: Specifies pulses for which measurement should be done.

Two options exist for the measurement:

- All Pulses
- Pulse Number

If the first option is selected, width is calculated for all pulses. If the second option is selected, width is calculated for the selected pulse.

Reference Level (%): Specifies the middle reference level of the waveform in percent, required to determine pulse width. Percentage is defined relative to the topline levels.

Apply measurement on: Specifies the range for the measurement.

Two options exist for the measurement:

- Entire waveform
- Selected range of waveform

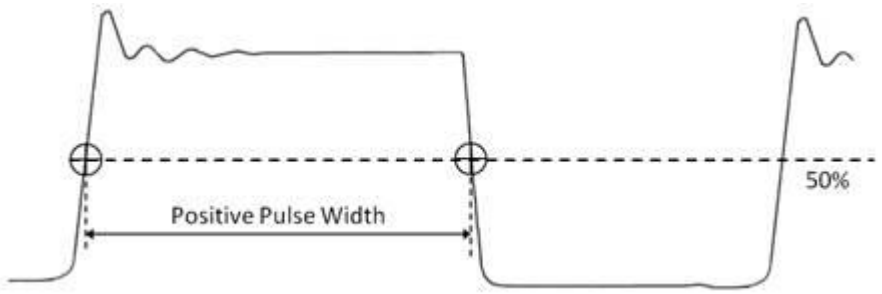
If the first option is selected, measurement is applied to the entire waveform, regardless of what is viewed, or selected with graph cursors.

If the second option is selected, measurement is applied only to the X range selected with the graph cursors.

Calculation

Pulse width for the positive pulse is calculated as the difference in time between reference level crossing of a rising edge and reference level crossing of the next falling edge of the waveform. Pulse width is calculated by finding two consecutive edges of the waveform.

Example of the positive pulse width calculation is shown with 50% reference level.



Negative Pulse Width

Description

Measures duration of the negative pulse of the waveform for the entire or selected range. Pulse width is the time difference between reference level crossings of the two adjacent edges of the pulse. Pulse width can be measured for all or selected pulses.

Measurement Category

Time Domain

Measurement Settings

Calculate for: Specifies pulses for which measurement should be done.

Two options exist for the measurement:

- All Pulses
- Pulse Number

If the first option is selected, width is calculated for all pulses. If the second option is selected, width is calculated for the selected pulse.

Reference Level (%): Specifies the middle reference level of the waveform in percent, required to determine pulse width. Percentage is defined relative to the topline levels.

Apply measurement on: Specifies the range for the measurement.

Two options exist for the measurement:

- Entire waveform
- Selected range of waveform

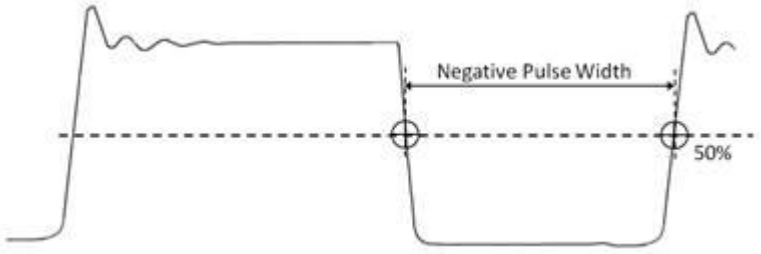
If the first option is selected, measurement is applied to the entire waveform, regardless of what is viewed, or selected with graph cursors.

If the second option is selected, measurement is applied only to the X range selected with the graph cursors.

Calculation

Pulse width for the negative pulse is calculated as the difference in time between reference level crossing of a rising edge and reference level crossing of the next falling edge of the waveform. Pulse width is calculated by finding two consecutive edges of the waveform.

Example of the negative pulse width calculation is shown with 50% reference level.



Rise Time

Description

Measures Rise time of the waveform between selected high and low reference levels for the entire or selected range. Rise time can be measured for all or selected pulses.

Measurement Category

Time Domain

Measurement Settings

Calculate for: Specifies pulses for which measurement should be done.

Two options exist for the measurement:

- All Pulses
- Pulse Number

If the first option is selected, rise time is calculated for all pulses. If the second option is selected, rise time is calculated for the selected pulse.

High Reference Level (%): Specifies the high reference level of the waveform in percent, required to determine transition interval. Percentage is defined relative to the topline levels. High reference level crossing defines the end of a rising transition interval.

Low Reference Level (%): Specifies the low reference level of the waveform in percent, required to determine transition interval. Percentage is defined relative to the baseline levels. Low reference level crossing defines the start of a rising transition interval.

Apply measurement on: Specifies the range for the measurement.

Two options exist for the measurement:

- Entire waveform
- Selected range of waveform

If the first option is selected, measurement is applied to the entire waveform, regardless of what is viewed, or selected with graph cursors.

If the second option is selected, measurement is applied only to the X range selected with the graph cursors.

Calculation

Rise time is calculated by finding crossing with the high and low reference levels of the waveform. Rise time is the time duration from when the waveform crosses the low reference level until it crosses the high reference level.

Example of rise time calculation is shown with 10% and 90% low and high reference levels respectively.

Fall Time

Description

Measures Fall time of the waveform between selected high and low reference levels for the entire or selected range. Fall time can be measured for all or selected pulses.

Measurement Category

Time Domain

Measurement Settings

Calculate for: Specifies pulses for which measurement should be done.

Two options exist for the measurement:

- All Pulses
- Pulse Number

If the first option is selected, fall time is calculated for all pulses. If the second option is selected, fall time is calculated for the selected pulse.

High Reference Level (%): Specifies the high reference level of the waveform in percent, required to determine transition interval. Percentage is defined relative to the topline levels. High reference level crossing defines the start of a falling transition interval.

Low Reference Level (%): Specifies the low reference level of the waveform in percent, required to determine transition interval. Percentage is defined relative to the baseline levels. Low reference level crossing defines the end of a falling transition interval.

Apply measurement on: Specifies the range for the measurement.

Two options exist for the measurement:

- Entire waveform
- Selected range of waveform

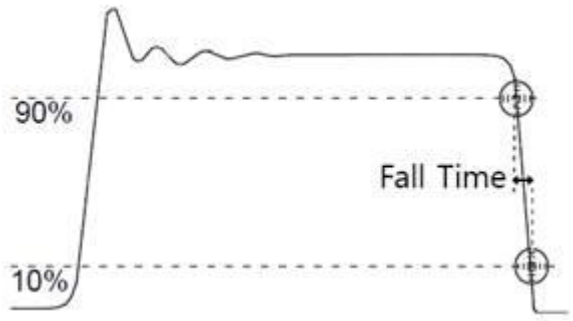
If the first option is selected, measurement is applied to the entire waveform, regardless of what is viewed, or selected with graph cursors.

If the second option is selected, measurement is applied only to the X range selected with the graph cursors.

Calculation

Fall time is calculated by finding crossing with the high and low reference levels of the waveform. Fall time is the time duration from when the waveform crosses the high reference level until it crosses the low reference level.

Example of fall time calculation is shown with 10% and 90% low and high reference levels respectively.



Slew Rate

Description

Measures Slew Rate of the specified edge of the waveform between selected high and low reference levels for the entire or selected range. Slew Rate can be measured for all or selected pulses.

Measurement Category

Time Domain

Measurement Settings

Calculate for: Specifies pulses for which measurement should be done.

Two options exist for the measurement:

- All Pulses
- Pulse Number

If the first option is selected, slew rate is calculated for the specified edges of all pulses. If the second option is selected, slew rate is calculated for the edge of the selected pulse.

Edge: Specifies the direction of the transition for which slew rate measurement should be done.

Two options exist for the measurement:

- Rising
- Falling

If the first option is selected, slew rate is calculated for rising edges. If the second options is selected, slew rate is calculated for the falling edges.

High Reference Level (%): Specifies the high reference level of the waveform in percent, required to determine transition interval. Percentage is defined relative to the topline levels. High reference level crossing defines the end of a rising transition interval and the start of a falling transition interval.

Low Reference Level (%): Specifies the low reference level of the waveform in percent, required to determine transition interval. Percentage is defined relative to the baseline levels. Low reference level crossing defines the start of a rising transition interval and the end of a falling transition interval.

Apply measurement on: Specifies the range for the measurement.

Two options exist for the measurement:

- Entire waveform
- Selected range of waveform

If the first option is selected, measurement is applied to the entire waveform, regardless of what is viewed, or selected with graph cursors.

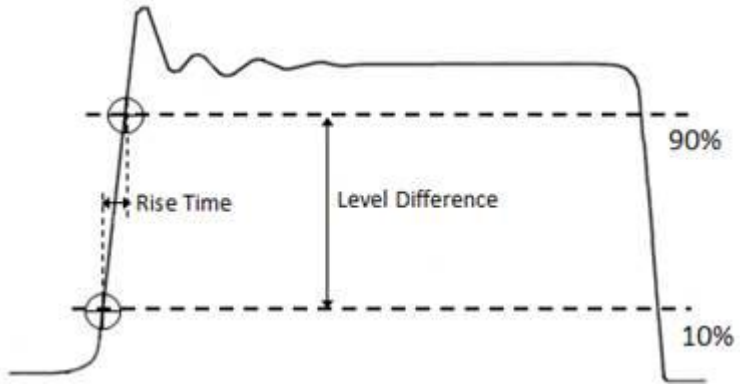
If the second option is selected, measurement is applied only to the X range selected with the graph cursors.

Calculation

Slew rate is calculated as the difference between the high and low reference levels of the waveform divided by the transition time of the edge. Transitions are defined by finding crossing with the high and low reference levels of the waveform.

$$Slew\ Rate = \frac{High\ Reference\ Level - Low\ Reference\ Level}{Transition\ duration}$$

Example of slew rate calculation is shown for rising edge with 10% and 90% low and high reference levels respectively.



Delay

Description

Measures Delay between the specified edges of two waveforms for the entire or selected range. Delay is the time difference between reference level crossings of the two consecutive edges of the two waveforms with the same polarity. Delay can be measured for all or selected pulses.

Measurement Category

Time Domain

Measurement Settings

Calculate for: Specifies pulses for which measurement should be done.

Two options exist for the measurement:

- All Pulses
- Pulse Number

If the first option is selected, delay is calculated for all pulses of two waveforms. If the second option is selected, delay is calculated for the selected pulses of two waveforms.

Edge: Specifies the direction of the edges for which delay measurement should be done.

Two options exist for the measurement:

- Rising
- Falling

If the first option is selected, delay is calculated between rising edges of two waveforms. If the second option is selected, delay is calculated between falling edges of two waveforms.

Reference Level (%): Specifies the middle reference level of the waveform in percent, required to determine delay. Percentage is defined relative to the topline levels.

Apply measurement on: Specifies the range for the measurement.

Two options exist for the measurement:

- Entire waveform
- Selected range of waveform

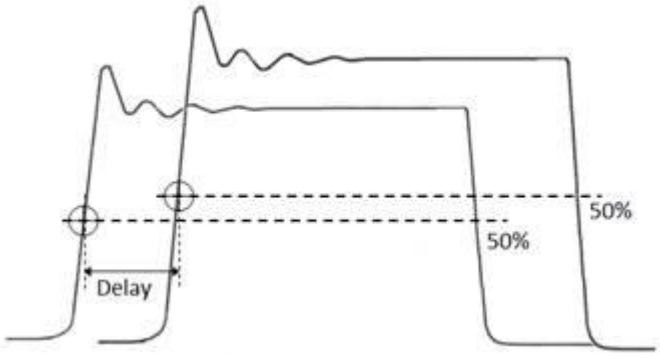
If the first option is selected, measurement is applied to the entire waveform, regardless of what is viewed, or selected with graph cursors.

If the second option is selected, measurement is applied only to the X range selected with the graph cursors.

Calculation

Delay is calculated as the difference in time between reference level crossing of a specified polarity edge of the first waveform and reference level crossing of the same polarity edge of the second waveform. Delay is calculated by finding two consecutive edges of the same polarity for two waveforms.

Example of the delay calculation is shown for the rising edges with 50% reference level.



Release Notes

1. Excel File Format

In the new version the program supports also files in Excel format.

2. Updated Menu Bar

2.1. Options - Open and Recent Files

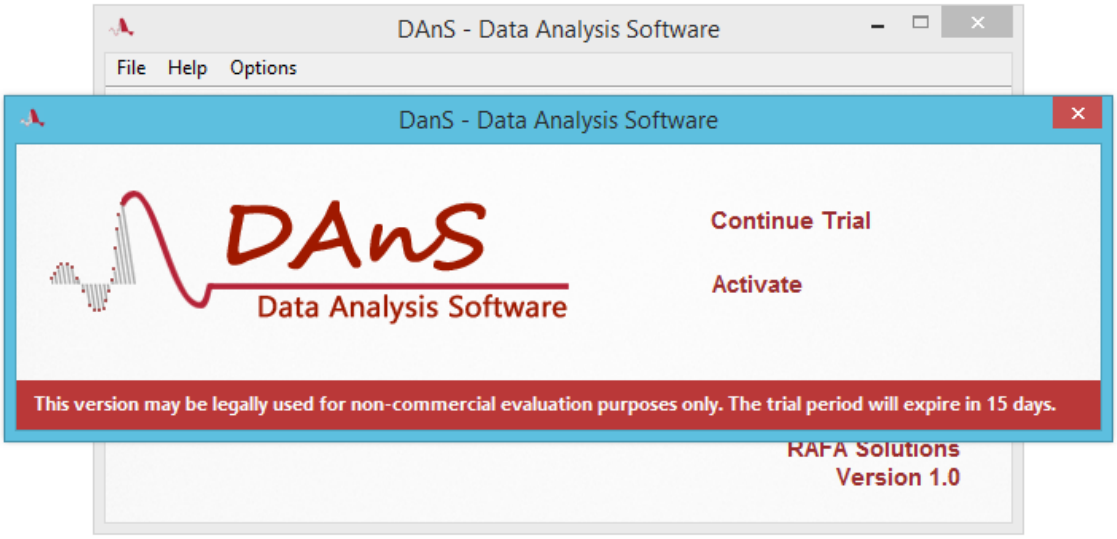
New options Open and Recent Files are added to the menu bar in Data Analysis Window. A file can be opened from the Data Analysis Window in the following way: File>Open. Recent Files: the program allows to open one of the recent files.

2.2. Options - Show Context Help Window

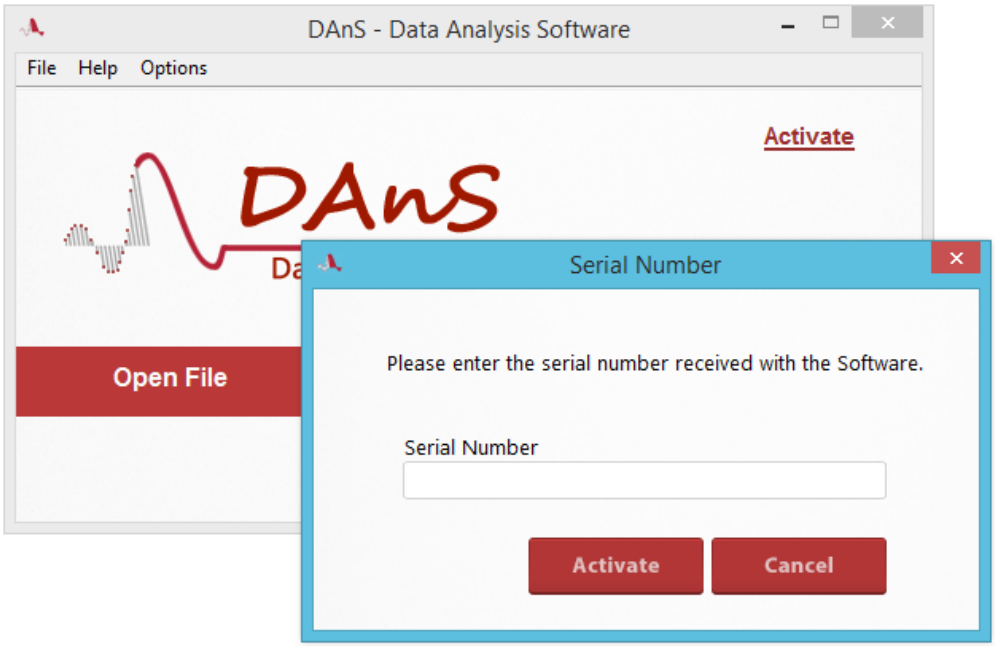
The new option Show Context Help Window is added to the menu bar in Data Analysis Window. It displays short description of object functions.

Software License and Evaluation

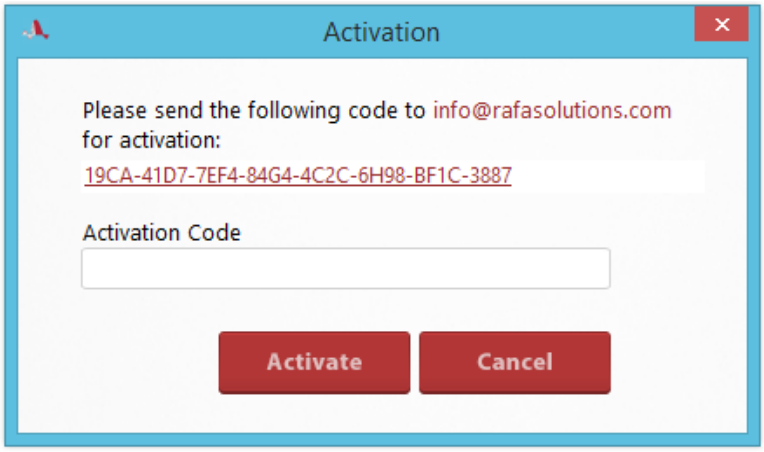
You can use the software without activation for 15 days for evaluation purposes. In this case you will see notification of days left each time you start the software.



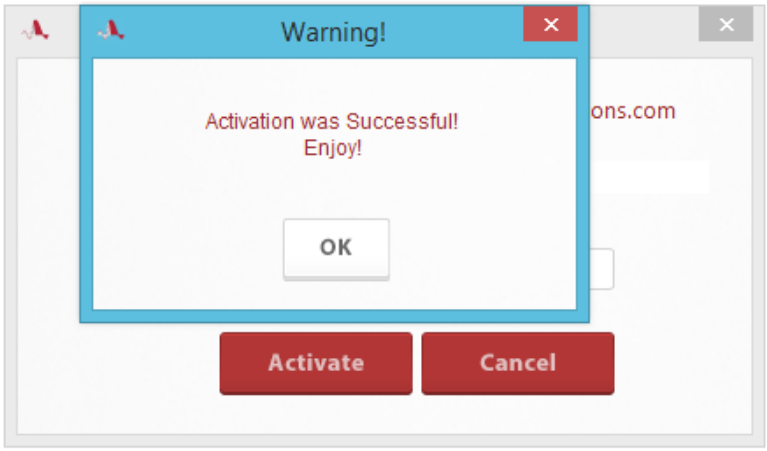
To activate software you should click the “Activate” button. The following window will be opened.



Enter the Serial Number, which you were provided. If entered serial number is correct, the following window will be opened for final activation. Shown code should be sent to the provided email address to get activation code.



If entered activation code is correct, the following window will appear.



License Agreement

END-USER LICENSE AGREEMENT

THIS END-USER LICENSE AGREEMENT ("AGREEMENT") IS A LEGAL AGREEMENT BETWEEN YOU AND THE LICENSOR.

YOU AGREE TO BE BOUND BY THE TERMS OF THIS AGREEMENT BY INSTALLING, COPYING, OR OTHERWISE USING THE PRODUCT AS SET FORTH IN THIS AGREEMENT. IF YOU DO NOT AGREE WITH THE TERMS OF THIS AGREEMENT, YOU SHOULD NOT INSTALL OR USE THE PRODUCT.

BY INSTALLING, COPYING, OR USING THE UPDATES OF THE PRODUCT (''UPDATES''), IF ANY, YOU AGREE TO BE BOUND BY THE ADDITIONAL LICENSE TERMS THAT MAY ACCOMPANY SUCH UPDATES. IF YOU DO NOT AGREE TO THE ADDITIONAL LICENSE TERMS THAT ACCOMPANY SUCH UPDATES, YOU SHOULD NOT INSTALL, COPY, OR USE SUCH UPDATES.

1. Definitions. As used herein, the following terms have the following meanings:

1.1. “You” or “Licensee” means the end user who legally received access to use the Software and the Product in accordance with the terms and conditions set forth herein.

1.2. “Licensor” means RAFA Solutions.

1.3. “Software” means the computer software provided to You by Licensor in accordance with the terms and conditions set forth herein.

1.4. “Product” means and includes the Software and all related printed or electronic materials, documentation, patches and fixes that may be provided or made available to You by Licensor.

1.5. “Permitted Purpose” means the right to use the Product or any portion thereof in accordance with the terms and conditions of this Agreement solely for the internal use of the Licensee.

2. License Grant. Licensor hereby grants to You and You hereby accept a limited, revocable, non-exclusive, non-transferable, non-assignable, non-sublicenseable license (hereinafter “License”) to:

2.1. access and use the Product or any portion thereof solely for the Permitted Purpose;

2.2. modify and create derivative works of the Software solely for the Permitted Purpose.

3. License Restrictions. The License is subject to the restrictions below. In particular, You are not allowed to:

3.1. alter any copyright, trademark or patent notice in the Product;

3.2. use Developer’s trademark/s in any way and for any purpose;

3.3. include the Product or any portion thereof in any malicious, deceptive or unlawful programs; or

3.4. distribute, provide access to or otherwise make the Product (as is or modified in accordance with the terms and conditions set forth herein) available to any third party.

3.5. work around any technical limitations in the Software;

3.6. reverse engineer, decompile or disassemble the Software, except and only to the extent that this Agreement expressly permits, despite this limitation;

3.7. use any components of the Product to run applications not running on the Software;

3.8. make more copies of the Product than specified in this Agreement;

3.9. disclose or distribute the Product or any portion thereof to any third party or publish them for others to copy;

3.10. rent, lease or lend the Product and/or any developments, improvements, modifications (made by You or Developer), further updates, upgrades thereof, notwithstanding whether they are made by the Developer, Installer, Licensor or by You to any third party; or

3.11. use the Product in any other manner not expressly stated in the Permitted Purpose.

4. Geographic Restrictions. You are only permitted to use this Product in the geographic region indicated on the Product, if any. You should not attempt to install and activate the Software outside of that region.

5. Intellectual Property Rights. The Software, and all copies of the Software, are (a) owned by Developer and protected by applicable copyright laws and international treaty provisions, and (b) licensed only, and not sold or leased. You shall not remove or alter any copyright, patent, trademark, or other legal notices or disclaimers that exist in the Software. All rights not expressly granted to You herein are reserved to Developer.

6. Backup Copy. You may make one backup copy (copies) of the Software. You may use it only to reinstall the Software.

7. Documentation. Any person that has valid access to your computer or internal network may copy and use the documentation for your internal, reference purposes.

8. Third Party Programs. The Software may contain third party programs. The license terms with those programs apply to your use of them.

9. Limitation on and Exclusion of Damages. No Party shall be liable for consequential damages, lost profits, special, indirect or incidental damages. This limitation applies to anything related to the software, services, content on third party Internet sites, or third party programs; as well as claims for breach of contract, breach of warranty, guarantee or condition, strict liability, negligence, or other tort to the extent permitted by applicable law. It also applies even if repair, replacement or a refund for the Software, if any does not fully compensate you for any losses; or Licensor knew or should have known about the possibility of the damages.

10. Limited Warranty. If you follow the instructions and the Software is properly licensed, the Software will perform substantially as described in the Licensor's materials that you receive in or with the Software. The limited warranty covers the software for 90 days after acquiring by you. If you receive supplements, updates, or replacement software during warranty period, they will be covered for the remainder of the warranty.

11. Exclusions from Warranty. This warranty does not cover problems caused by your acts (or failures to act), the acts of others, or events beyond the reasonable control of the Licensor.

12. Remedy for Breach of Warranty. Licensor will, at its election, either (i) repair or replace the Software at no charge, within the warranty term, or (ii) accept return of the product(s) for a refund of the amount paid, if any. The developer, Licensor or installer may also repair or replace supplements, updates and replacement software or provide a refund of the amount you paid for them, if any. These are your only remedies for breach of the limited warranty.

13. No other Warranties. The limited warranty is the only direct warranty from the developer, Licensor or installer. The latters give no other express warranties, guarantees or conditions and exclude implied warranties of merchantability, fitness for a particular purpose and non-infringement.

14. Disclaimer of Warranties. The Limited Warranty referenced herein is the only express warranty made to you and is provided in lieu of any other express warranties (if any). Except for the Limited Warranty, Licensor and its suppliers provide the Product and support services (if any) AS IS AND WITH ALL FAULTS, and hereby disclaim all other warranties and conditions, either express, implied, or statutory, including, but not limited to, any (if any) implied warranties, duties or conditions of merchantability, of fitness for a particular purpose, of accuracy or completeness of responses, of results, of workmanlike effort, of lack of viruses, and of lack of negligence, all with regard to the Product, and the provision of or failure to provide support services. ALSO, THERE IS NO WARRANTY OR CONDITION OF TITLE, QUIET ENJOYMENT, QUIET POSSESSION, AND CORRESPONDENCE TO DESCRIPTION OR NON-INFRINGEMENT.

15. EXCLUSION OF INCIDENTAL, CONSEQUENTIAL, AND OTHER DAMAGES. IN NO EVENT SHALL LICENSOR AND/OR ITS SUPPLIERS, DISTRIBUTORS BE LIABLE FOR ANY SPECIAL, INCIDENTAL, INDIRECT, OR CONSEQUENTIAL DAMAGES WHATSOEVER (INCLUDING, BUT NOT LIMITED TO, DAMAGES FOR LOSS OF PROFITS OR CONFIDENTIAL OR OTHER INFORMATION, FOR BUSINESS INTERRUPTION, FOR PERSONAL INJURY, FOR LOSS OF PRIVACY, FOR FAILURE TO MEET ANY DUTY INCLUDING OF GOOD FAITH OR OF REASONABLE CARE, FOR NEGLIGENCE, AND FOR ANY OTHER PECUNIARY OR OTHER LOSS WHATSOEVER) ARISING OUT OF OR IN ANY WAY RELATED TO THE USE OF OR INABILITY TO USE THE PRODUCT, THE PROVISION OF OR FAILURE TO PROVIDE SUPPORT SERVICES, OR OTHERWISE UNDER OR IN CONNECTION WITH ANY PROVISION OF THIS AGREEMENT, EVEN IN THE EVENT OF THE FAULT, TORT (INCLUDING NEGLIGENCE), STRICT LIABILITY, BREACH OF CONTRACT, OR BREACH OF WARRANTY OF LICENSOR OR ANY SUPPLIER, AND EVEN IF LICENSOR OR ANY SUPPLIER HAS BEEN ADVISED OF THE POSSIBILITY OF SUCH DAMAGES.

16. Limitation of Liability and Remedies. Notwithstanding any damages that you might incur for any reason whatsoever (including, without limitation, all damages referenced above and all direct or general damages), the entire liability of Licensor and any of its suppliers, distributors under any provision of this Agreement and your exclusive remedy for all of the foregoing (except for any remedy of repair or replacement elected by Licensor with respect to any breach of the Limited Warranty) shall be limited to the greater of the amount actually paid by you for the Product. The foregoing limitations, exclusions, and disclaimers (including Sections 9 and 10 above and as stated in the Limited Warranty) shall apply to the maximum extent permitted by applicable law, even if any remedy fails its essential purpose.

17. Consent to use of Data. You agree that Licensor and/or its affiliates may collect and use technical information you provide as a part of support services, if any, related to the Product. Licensor agrees not to use this information in a form that personally identifies you.

18. Prerelease Code. The Product or any portion thereof may be identified as prerelease code ("Prerelease Code"). Such Prerelease Code may be not at the level of performance and compatibility of the final Product. The Prerelease Code may not operate correctly and may be substantially modified. The grant of license to use Prerelease Code expires upon availability of the final version (including trial version) of the Product.

19. Update License Terms. All updates shall be considered part of the Product and subject to the terms and conditions of this Agreement. Additional license terms may accompany Updates, as defined above. By installing, copying, or otherwise using any Update, you agree to be bound by the terms accompanying each such Update. If you do not agree to the additional license terms accompanying such Updates, you should not install, copy, or otherwise use such Updates.

20. Entire Agreement. This Agreement (including any addendum or amendment to this Agreement) are the entire agreement between you and Licensor relating to the Product and the Support Services (if any) and they supersede all prior or contemporaneous oral or written communications, proposals, and representations with respect to the Product or any other subject matter covered by this Agreement. To the extent the terms of any Licensor policies or programs for Support Services conflict with the terms of this Agreement, the terms of this Agreement shall control.

21. Applicable Law. The law of the country of registration of the Licensor governs the interpretation, execution and performance of this Agreement.

22. Termination. Without prejudice to any other rights, Licensor may cancel this Agreement if you do not abide by the terms and conditions of this Agreement, in which case you must destroy all copies of the Product.